
ADDITIONS TO THE EOCENE MEGAFOSSIL FAUNA OF THE LLAJAS FORMATION, SIMI VALLEY, SOUTHERN CALIFORNIA

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ABSTRACT. Thirty-two previously unreported shallow marine megafossils are recorded for the Eocene Lajas Formation, Simi Valley, Ventura County, California. Illustrations, synonymies, primary type material information, Pacific coast of North American molluscan stage ranges, geographic distributions, local occurrences, and remarks are provided for the taxa, which include one colonial coral, two solitary corals, two brachiopods, nine gastropods, 10 bivalves, one nautiloid, one lobster, three crabs, one sea urchin, one shark, and one bat ray. Four new species are described and named: the turrid gastropods ?*Cochlespiopsis jenkinsi* and *Bathytoma pacifica*; the scyllarid lobster *Parribacus caesius*; and the raninid crab *Raninoides slaki*.

In addition to the 32 previously unreported megafossils, one gastropod, one cassiduloid echinoid, and one spatangoid echinoid are included. These additional three megafossils were previously reported from the Lajas Formation, but no photographs of any specimens had been provided.

Parribacus caesius is the first Tertiary record of this genus. The Lajas Formation occurrence of the hexapod crab *Palaeopinnixa* aff. *P. rathbunae* Schweitzer et al., 2000, is the first record of this genus from California. ?*Cochlespiopsis jenkinsi*, *B. pacifica*, and the sea urchin ?*Brochopleurus* sp. are the first records of these genera on the Pacific coast of North America. The Lajas Formation occurrence of the nautiloid *Kummelonautilus* sp. is the earliest record of this genus on the Pacific coast of North America and its first record in California. The volutid gastropod "*Voluta*" *eomagna* Vokes, 1939, which occurs in the Lajas Formation, is herein provisionally identified as *Lapparia eomagna*.

Recent taxonomic revisions of Lajas Formation species previously reported by the author are mentioned.

INTRODUCTION

Squires (1984) wrote a monograph on the megafossils of the Eocene Lajas Formation that crops out in Simi Valley, Ventura County, southern California. Illustrations, synonymies, and other pertinent data were given for 107 species and subspecies. In addition, the depositional environments, stratigraphic distribution, paleoclimate, geologic age, correlation, and biogeography of these fossils were also discussed.

Since 1984, new fossil material from the Lajas Formation has been found. This material comes from both a meticulous search of the invertebrate paleontology collection of the Natural History Museum of Los Angeles County and from recent collecting by private individuals, by the author, and by the author's students. It is the purpose of this paper to report and illustrate these additions to the megafauna. Illustrations, synonymies, and other pertinent data are given for 32 species. The taxa are one colonial coral, two solitary corals, two brachiopods, nine gastropods, 10 bivalves, one nautiloid, one lobster, three crabs, one sea urchin, one shark, and one bat ray. Two of the gastropods, the lobster,

and one of the crabs are new species and are described and named here.

All megafossil taxa known with certainty in the Lajas Formation, including those covered in this report, are tabulated in the Appendix. There are a total of 138; namely, five corals, three brachiopods, one polychaete, two scaphopods, 72 gastropods, 39 bivalves, three cephalopods, five crabs, four echinoderms, and four sharks/rays.

The pseudovoline gastropod *Calorebama inornata* (Dickerson, 1915), the cassiduloid echinoid *Calilampas californiensis* Squires and Demetron, 1992, and the spatangoid echinoid *Eupatagus stevensi* Grant and Hertlein, 1938, are included in the present study. Although all three were previously reported from the Lajas Formation, no photographs had been provided, and the locality information provided for the spatangoid echinoid was inexact.

A total of 210 megafossil specimens from 19 localities (Figs. 1–3) represents the basis for this report. Most of the species represented in this study are rarely found in the Lajas Formation. Only the gastropod *Mitra simplicissima* Cooper, 1894, and the crab *Raninoides slaki* n. sp. are common, but both are very localized in their distribution. Preservation of all the fossils mentioned in this report ranges from poor to good, and many are badly weathered or occur as internal molds.

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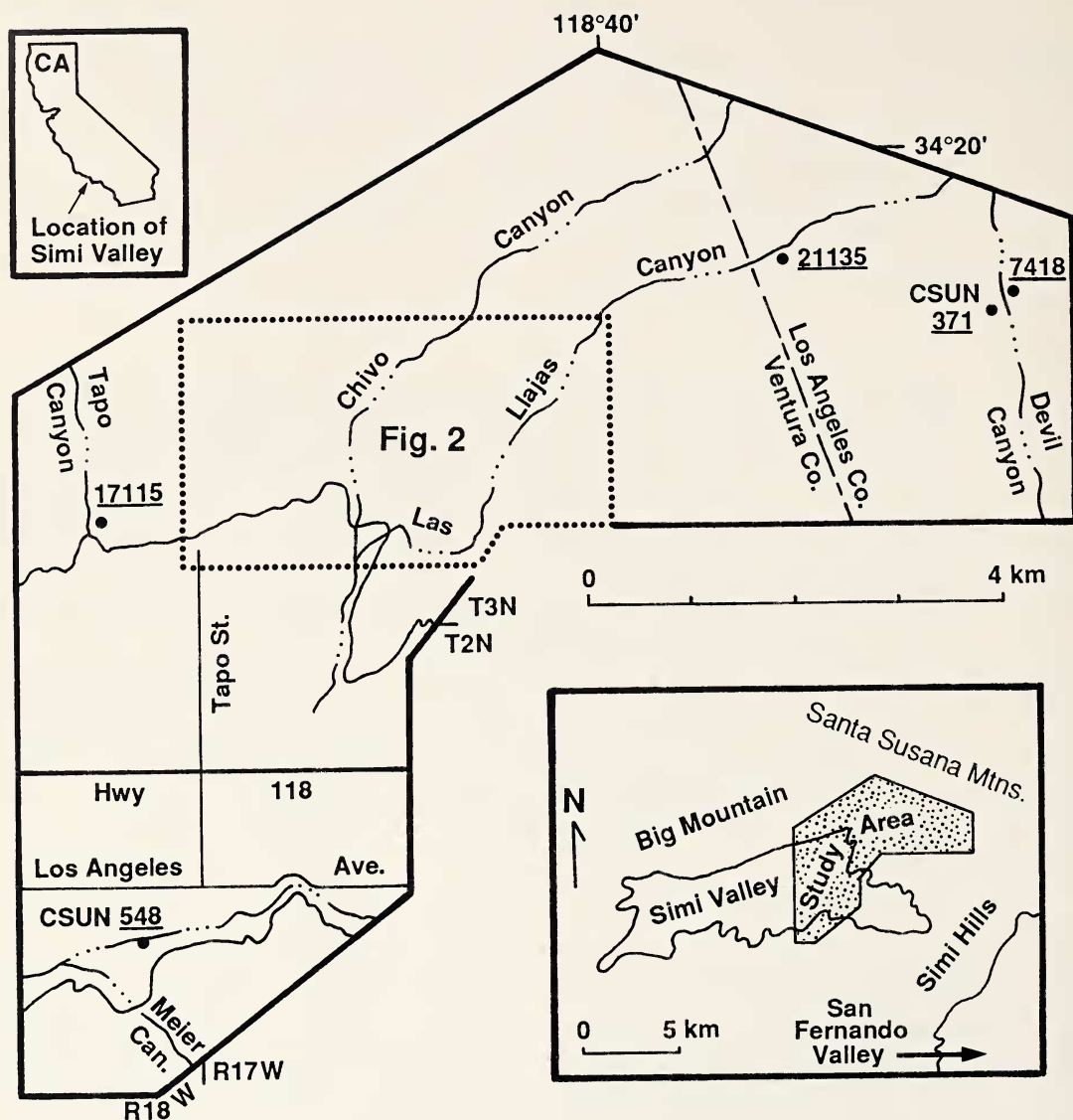


Figure 1 Index map of Simi Valley showing area used for Figure 2 and megafossil localities located outside of Figure 2 (= LACMIP localities, unless otherwise noted)

Between 1984 and the present report, there have been three new species and three previously named species reported from the Lajas Formation. One of the new species is the vermetid gastropod *Serpulorbis llajasensis* Squires, 1990, reported by Squires (1990). The second new species is the epitoniid gastropod *Cirsotrema eocenica* Squires and Demetron, 1994. This species is also known from the "Domengine Stage" part of the Bateque Formation in Baja California Sur, Mexico (Squires and Demetron, 1994). The third new species is the cassiduloid echinoid *C. californiensis*. This echinoid is primarily known from Eocene rocks in Baja California Sur, Mexico, and only a single specimen of *C. californiensis* is known from the Lajas Formation (Squires

and Demetron, 1992). As mentioned above, this specimen previously was not illustrated, but photographs are included in this report. The three previously named species are the campanilid gastropod *Campanile dilloni* (Hanna and Hertlein, 1949), reported by Squires (1993); the gastropod *Loxotrema turritum* Gabb, 1868, tentatively reported by Squires (1998); and the pseudolivine gastropod *C. inornata* (Dickerson, 1915), reported by Squires (1989). As mentioned above, Lajas specimens of this latter species previously were not illustrated, but a photograph is included in this report.

Recent taxonomic revisions of previously reported species from the Lajas Formation are mentioned herein.

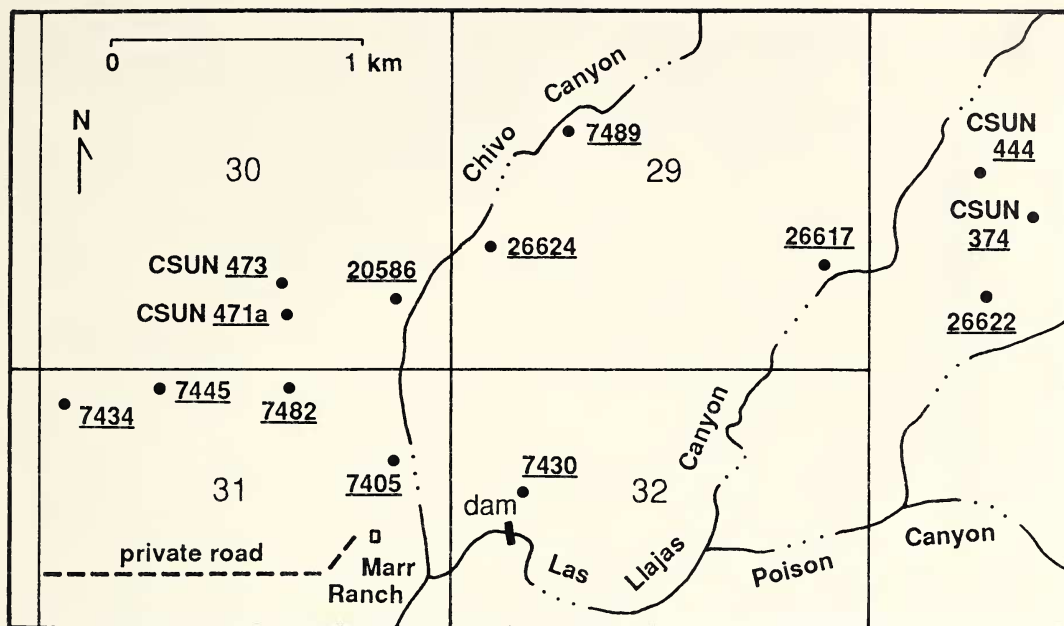


Figure 2 Index map of a portion of the north side of Simi Valley showing most of the megafossil localities (= LACMIP localities, unless otherwise noted) used in this study. Locations of the additional localities are shown in Figure 1. Base map is U.S. Geological Survey 7.5-minute Santa Susana quadrangle, 1951 (photorevised 1969), Ventura County, California

The molluscan stage terminology used in this report includes the upper Paleocene "Martinez Stage," the uppermost Paleocene to lowermost Eocene "Meganos Stage," the middle lower "Capay Stage," the upper lower to lower middle "Domengine Stage," the lower middle "Transition Stage," and the middle middle Eocene to upper Eocene "Tejon Stage." The stage names are in quotes because they are informal terms and generally equivalent to formation names. A historical overview of these stage names was given by Clark and Vokes (1936). Givens (1974) modified the use of the "Capay Stage," and it is in this modified sense that the "Capay Stage" is used here. Saul (1983) and Squires (1984, 1987, 1988a) regarded the modified "Capay Stage" of Givens (1974) as middle lower Eocene.

GEOLOGIC OVERVIEW

In a vertical sense, the Lajas Formation is a transgressive sedimentary sequence followed by a regressive one (Fig. 3). The transgressive sequence consists of facies that grade vertically upward from nonmarine coastal alluvial fan, to shallow marine, to outer shelf, to slope with localized incised channels filled with turbidites. These channels and associated outer shelf to slope facies were subsequently covered by a regressive shallow marine facies. The regressive cycle is incomplete due to erosional truncation by the nonmarine Sespe Formation (Squires, 1981).

The nonmarine coastal alluvial fan facies is a boulder conglomerate that is unfossiliferous, but the zone of interfingering between this facies and the transgressive shallow marine facies contains moderately abundant fossils, most of which were concentrated into coquinas by rough-water conditions along the shoreline. These fossils, as well as associated small-sized benthic foraminiferans, are indicative of the "Capay Stage." The remaining lower half of the formation is made up of the transgressive shallow marine facies, which consists of alternating laminated and bioturbated sandstone that accumulated in a shoreface to upper offshore environment (2 to 21 m deep), with the shoreface environment the most common. The fossiliferous beds are scattered and mostly confined to storm-caused channels. The fossils underwent a short distance of postmortem transport and constitute indigenous death assemblages (Squires, 1981, 1984).

Where the sandstone of the transgressive shallow marine facies grades into muddy siltstone of the sparsely fossiliferous outer shelf and slope facies, there is a widespread 1-m-thick layer informally known as the "Stewart bed." This bed is richly fossiliferous and represents a molluscan-solitary coral paleocommunity that formed near the shelf/slope break (Squires, 1981, 1983, 1984). Many of the species mentioned in this report are from CSUN locality 374 in the "Stewart bed," or from CSUN locality 548, which is slightly stratigraphically below the "Stewart bed" (Fig. 3).

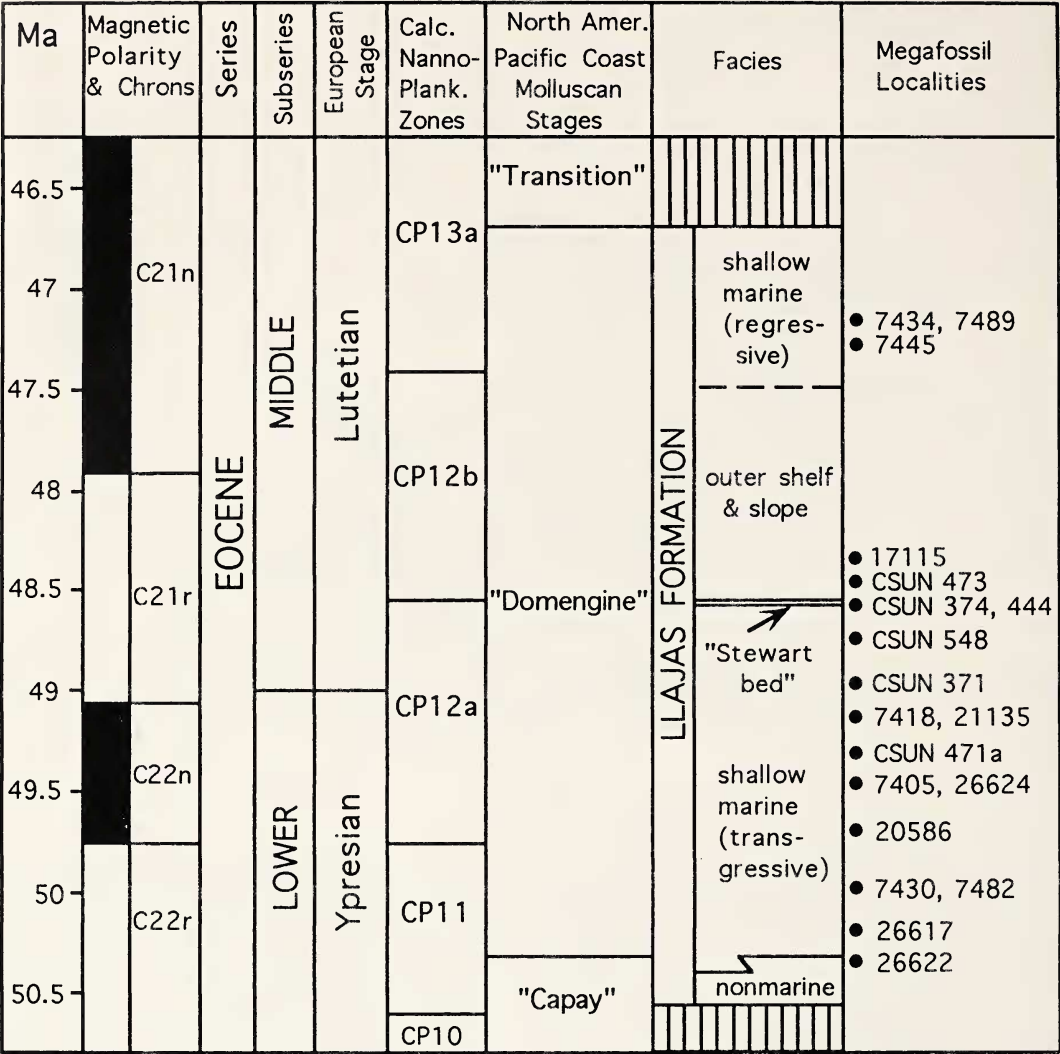


Figure 3 Stratigraphic column of the Llajas Formation; showing position of megafossil localities (= LACMIP localities, unless otherwise noted). Geochronologic time scale, magnetic polarity and chrons, series, subseries, European stages, and calcareous nannofossil zones from Berggren et al. (1995); North America Pacific coast molluscan stages from Squires (1988a, 1998); and facies from Squires (1984)

The sandstone of the regressive shallow marine facies makes up the uppermost part of the formation. It consists of bioturbated silty sandstone with minor occurrences of laminated sandstone and scattered fossiliferous units. These deposits were in slightly deeper waters than those of the transgressive shallow marine facies and were less affected by storm reworking (Squires, 1983, 1984).

All the megafossils stratigraphically above the "Capay Stage" part of the Llajas Formation are indicative of the "Domengine Stage." Associated small-sized benthic foraminiferans and calcareous nannofossils corroborate this stage assignment. A magnetostratigraphic study of the Llajas Formation recognized Chrons C22n, C21r, and C21n (Bottjer

et al., 1991). These correlate to the calcareous nannoplankton zones CP11 and CP12 (Berggren et al., 1995), which correlate to the "Domengine Stage" (Squires, 1984, 1987, 1988a; Squires and Demetron, 1992) (Fig. 3).

The Llajas Formation fauna lived in tropical (20°C or warmer) waters. As reviewed by Squires (1987), the world climate was relatively warm and equable during most of the Paleocene through early middle Eocene, and a worldwide late Paleocene warming trend culminated in a period of peak warming during the early Eocene. As also reviewed by Squires (1998), humid tropical climatic conditions were prevalent during the late Paleocene to early middle Eocene in coastal lowland areas from

Baja California, Mexico, to southwestern Washington. The late Paleocene and early Eocene were times of major immigration of Old World Tethyan megainvertebrates into the Pacific coast region of North America via a seaway, most likely through the Central America seaway (Clark and Vokes, 1936; Givens, 1978; Squires, 1984, 1987, 1999).

TAXONOMIC REVISIONS OF SPECIES PREVIOUSLY REPORTED FROM THE LLAJAS FORMATION

Squires (1984:16, fig. 6a) reported specimens of the neritid gastropod *Nerita* cf. *N. (Amphinerita) eorex* Vokes, 1939, from the "Capay Stage" part of the Llajas Formation. Saul and Squires (1997:135) reported that these specimens are actually juveniles of *Velates perversus* (Gmelin, 1791).

The epitoniid gastropod *Cirsotrema* sp. (Squires, 1984:21, fig. 6p) from the Llajas Formation "Stewart bed" was reported by Squires and Demetron (1994) to be conspecific with *C. eocenica* Squires and Demetron, 1994, whose type locality is in the "Domengine Stage" part of the Bateque Formation, San José de Gracia area, Baja California Sur, Mexico.

Squires (1984:23–24, fig. 7b) reported the cypræid gastropod *Cypraea castacensis* Stewart, 1927, from the "Domengine Stage" part of the Llajas Formation. Refinements in taxonomy by Groves (1992) allow this species to be referred to *Eocypraea (Eocypraea) castacensis* (Stewart).

Squires (1984:37, 39, fig. 9k) reported specimens of the turrid gastropod *Domenginella claytonensis* (Gabb, 1864) from the "Capay Stage" and "Domengine Stage" parts of the Llajas Formation. These specimens actually belong to the turrid *Trypanotoma stocki* (Dickerson, 1916), and this correction was reported by Squires (1988a, 1988b). Discussion and illustrations of this species, which is also known from the Domengine Formation ("Domengine Stage") in Fresno County, California, are also given in Dickerson (1916:499–500:pl. 42, fig. 5) and Vokes (1939:120, pl. 17, fig. 14).

Squires (1984:31, fig. 8f) reported *Molopophorus cretaceus* (Gabb, 1864) from the "Domengine Stage" part of the Llajas Formation. Allmon (1990:70), in his taxonomic refinement of the generic assignment of this species, referred to it as *Cohwellia cretacea*.

SYSTEMATIC MATERIALS AND METHODS

Systematic arrangement of the higher taxa follows that of Wells (1956) for the scleractinians, Muir-Wood (1965) and Muir-Wood et al. (1965) for the brachiopods, Vokes (1980) for the bivalves, Kummel (1964) for the nautiloid, Glaessner (1969) for the lobster and crabs, Fell and Pawson (1966) for the sea urchin, Fischer (1966) for the casiduloid and spatangoid echinoids, and Capetta (1987) for the shark and bat ray. The higher classification of gastropods is in a state of flux, and some of the categories used here for suprafamilial names are referred to as sub-

classes or superorders and generally correspond to major clade names used by Ponder and Lindberg (1996, 1997).

Synonymies (including primarily only figured specimens), primary type material, molluscan stage range, and geographic distribution data are given for the identifiable species. Abbreviations for catalog and/or locality numbers are as follows.

ANSP	Academy of Natural Sciences, Philadelphia.
CAS	California Academy of Sciences, San Francisco.
CSUN	California State University, Northridge.
IGM	Instituto de Geología, Universidad Nacional Autónoma de México, Mexico City.
LACMIP	Natural History Museum of Los Angeles County, Invertebrate Paleontology Section.
LACMVP	Natural History Museum of Los Angeles County, Vertebrate Paleontology Section.
UCLA	University of California, Los Angeles (collections now housed at the Natural History Museum of Los Angeles County).
UCMP	University of California, Museum of Paleontology, Berkeley.
UCR	University of California, Riverside.
USNM	United States National Museum, Washington, D.C.

The bulk of the material used in this study is housed at LACMIP. The remainder is housed at CSUN. New species primary type material and hypotypes of the invertebrate fossils used for illustrations in this report are deposited at LACMIP. The odontapsid shark and bat ray teeth hypotypes are deposited at LACMVP.

SYSTEMATICS

Phylum Cnidaria Hatschek, 1888

Class Anthozoa Ehrenberg, 1834

Order Scleractinia Bourne, 1900

Family Oculinidae Gray, 1847a

Genus *Archobelia* Vaughan, 1919

TYPE SPECIES. *Archobelia limonensis* Vaughan, 1919, by original designation; Pliocene, Costa Rica.

Archobelia clarki Vaughan, 1927

Figure 4

Archobelia clarki Vaughan, 1927:143, pl. 23, figs. 1–5; Squires, 1999:13, figs. 20, 21.

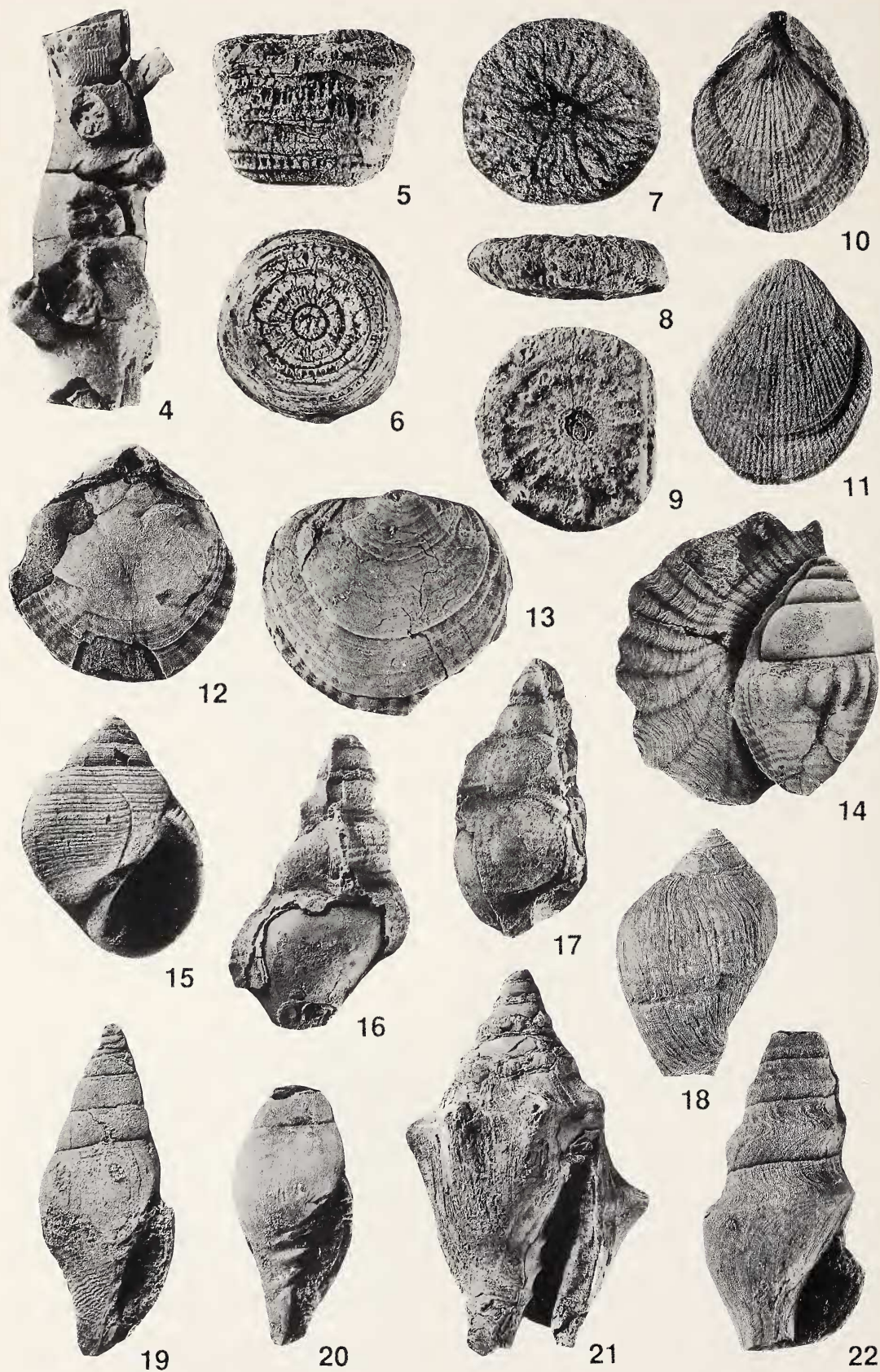
PRIMARY TYPE MATERIAL. UCMP holotype 31414 and UCMP paratype 31415; UCMP locality 3609, "Meganos Formation," north of Mt. Diablo, Contra Costa County, California.

MOLLUSCAN STAGE RANGE. "Meganos" and "Domengine" (no specimens known from "Capay Stage").

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, and north of Mt. Diablo, Contra Costa County, California.

LOCAL OCCURRENCE. LACMIP locs. 7482, 22312.

REMARKS. Three small, fragmentary specimens are from LACMIP locality 22312, and one larger



fragment is from LACMIP locality 7482. The latter shows the branching, colonial form and the septa.

Archohelia clarki is the only known species of this oculinid coral genus from the Pacific coast of North America fossil record. The Llajas Formation occurrence of this species represents the first record of this coral in "Domengine Stage" strata. Prior to this study, *A. clarki* was only known from "Meganos Stage" strata (Squires, 1999).

Family Mussidae Ortmann, 1890

Genus *Antilla* Duncan, 1863

TYPE SPECIES. *Antilla dentata* Duncan, 1863, by subsequent designation (Fromental, 1867); Miocene, Dominican Republic.

Antilla batequensis Squires and Demettrion, 1992

Figures 5, 6

Antillia batequensis Squires and Demettrion, 1992: 21, 22, figs. 39–42.

PRIMARY TYPE MATERIAL. IGM holotype 5145 and IGM paratypes 5146, 5147; all types from CSUN locality 1291a, Bateque Formation, Baja California Sur, Mexico.

MOLLUSCAN STAGE RANGE. "Capay" and "Domengine."

GEOGRAPHIC DISTRIBUTION. Eastern Laguna San Ignacio area, Baja California Sur; San Diego, California, and Simi Valley, California.

LOCAL OCCURRENCE. Exact locality unknown, but in vicinity of LACMIP loc. 7434.

REMARKS. A single specimen is known from the Llajas Formation. The specimen is complete and well preserved, except that the dorsal-central region of the calyx is missing. Most of the very thin membraniform epitheca is intact, and the base with its small, pointed apex in the center is well developed.

The Llajas Formation occurrence of this species

represents only the second record of this coral in "Domengine Stage" strata. Prior to this study, *Antilla batequensis* was only known from the "Capay Stage" part of the Bateque Formation in Baja California Sur, Mexico, and from the "Domengine Stage" Ardath Shale in San Diego County, California (Squires and Demettrion, 1992).

Family Caryophylliidae Gray, 1847a

Genus *Trochocyathus* Milne-Edwards and Haime, 1848

TYPE SPECIES. *Turbinolia mitrata* Goldfuss, 1827, by subsequent designation (Milne-Edwards and Haime, 1850); Miocene, Germany.

Genus *Trochocyathus stantoni* Vaughan, 1900

Figures 7–9

Trochocyathus stantoni Vaughan, 1900:98–99, pl. 7, figs. 18, 18a.

PRIMARY TYPE MATERIAL. USNM holotype M158158 (in the Mollusk Paleontology ledger) from "Tejon Group" 4 km NE of Clayton, Contra Costa County, California.

MOLLUSCAN STAGE RANGE. "Domengine."

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, to near Clayton, Contra Costa County, California.

LOCAL OCCURRENCE. LACMIP loc. 17115, CSUN locs. 473, 548.

REMARKS. Thirteen specimens are known from the Llajas Formation. Seven are from glauconitic siltstone at CSUN locality 473, five are from LACMIP locality 17115, and a single specimen is from CSUN locality 548.

Trochocyathus stantoni is distinguished by its discoid shape and its flat base with a scar in the center, as if it were attached. The Llajas Formation occurrence of *Trochocyathus stantoni* is the first record of this species in southern California. Prior to

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Figures 4–22 Colonial coral, solitary corals, articulate brachiopods, and gastropods from the Llajas Formation. All specimens coated with ammonium chloride. 4. Colonial coral, *Archohelia clarki* Vaughan, 1927, lateral view, $\times 2.5$, LACMIP hypotype 12727, LACMIP loc. 7482. 5–9. Solitary corals. 5, 6. *Antilla batequensis* Squires and Demettrion, 1992, $\times 1.1$, LACMIP hypotype 12728, vicinity of LACMIP loc. 7434. 5. Lateral view. 6. Ventral view. 7–9. *Trochocyathus stantoni* Vaughan, 1900. 7, 8. $\times 3.1$, LACMIP hypotype 12729, CSUN loc. 473. 7. Dorsal view. 8. Lateral view. 9. Basal view, $\times 4.5$, LACMIP hypotype 12730, LACMIP loc. 17115. 10–13. Articulate brachiopods. 10, 11. *Terebratulina* cf. *Terebratulina tejonensis* Stanton, 1896, $\times 3.1$, LACMIP hypotype 12731, LACMIP loc. 21135. 10. Brachial valve. 11. Pedicle valve. 12, 13. *Terebratalia* aff. *Terebratalia batequia* Sandy, Squires, and Demettrion, 1995, $\times 1.9$, CSUN loc. 548. 12. Brachial valve, LACMIP hypotype 12732. 13. Pedicle valve, LACMIP hypotype 12733. 14–22. Gastropods. 14. *Platyoptera pacifica* Squires and Demettrion, 1990a, abapertural view, $\times 1.3$, LACMIP hypotype 12734, CSUN loc. 548. 15. *Amaurellina caleocia* Vokes, 1939, apertural view, $\times 5.2$, LACMIP hypotype 12735, LACMIP loc. 7418. 16, 17. *Pterynotus* (*Pterynotus*) cf. *Pterynotus* (*Pterynotus*) *washingtonicus* Squires and Goedert, 1995, $\times 1.5$, LACMIP hypotype 12736, LACMIP loc. 16654. 16. Abapertural view. 17. Left-lateral view. 18. *Calorebama inornata* (Dickerson, 1915), apertural view, $\times 1.6$, LACMIP hypotype 12737, LACMIP loc. 7445. 19, 20. *Mitra simplicissima* Cooper, 1894, $\times 4.4$, LACMIP loc. 20586. 19. Apertural view, LACMIP hypotype 12738. 20. Apertural view, upper spire missing, LACMIP hypotype 12739. 21. *Lapparia eomagna* (Vokes, 1939), apertural view, $\times 0.9$, LACMIP hypotype 12740, LACMIP loc. 22312. 22. ?*Cochlespiropsis jenkinsi* n. sp., apertural view, $\times 1.6$, LACMIP holotype 12741, LACMIP loc. 22312

this study, *T. stantoni* was only known from “Domengine Stage” strata in northern California (Vaughan, 1900).

Phylum Brachiopoda Duméril, 1806

Class Articulata Huxley, 1869

Order Terebratulida Waagen, 1883

Family Cancellothyrididae Thomson, 1926

Genus *Terebratulina* d’Orbigny, 1847a

TYPE SPECIES. *Anomia retusa* Linnaeus, 1758 [= *A. caputserpentis* Linnaeus, 1767], by original designation; Recent, Norway.

Terebratulina cf. *Terebratulina tejonensis*
Stanton, 1896
Figures 10, 11

LOCAL OCCURRENCE. LACMIP loc. 21135.

REMARKS. A single specimen is known from the Llajas Formation. It is complete but slightly crushed. The specimen resembles some forms of *T. tejonensis* Stanton (1896:1037–1038, pl. 63, figs. 3, 4). Dickerson (1914:73, pl. 7, fig. 2a, 2b) and Hertlein and Grant (1944:75–77, pl. 5, figs. 5, 6, text fig. 19) also discussed and illustrated Stanton’s species. *Terebratulina tejonensis* has been reported from the upper Paleocene Martinez Formation at a few places in northern California and from “lower Eocene” rocks on Santa Cruz Island, Santa Barbara County, California (Stanton, 1896; Dickerson, 1914; Hertlein and Grant, 1944). It has also been reported from the Llajas Formation, but no specific localities were mentioned, other than an oil well core hole (Hertlein and Grant, 1944). These particular Llajas specimens were not given museum catalog numbers. The Llajas specimen from LACMIP locality 21135 is very similar to the illustration of the slender variety of *T. tejonensis* given by Stanton (1896:pl. 63, fig. 3). The similarities are the elongate-ovate shape, moderately convex valves, and surface marked by small but prominent radiating ribs that can bifurcate. Unfortunately, the specimen from locality 21135 is crushed, and it cannot be determined whether or not it has the obscure median depression in the pedicle valve that is present on *T. tejonensis*. Also, there is considerable variation in the degree of elongation of *T. tejonensis*, with some (most?) specimens much wider than the specimen from locality 21135. More and better preserved specimens of *Terebratulina* cf. *T. tejonensis* from the Llajas Formation are needed to confirm the species identification.

Family Laqueidae Thomson, 1927, emended
Richardson, 1975

Genus *Terebratalia* Beecher, 1893

TYPE SPECIES. *Terebratula transversa* Sowerby, 1846, by original designation; Recent, Alaska to northern Baja California, Mexico.

Terebratalia aff. *Terebratalia batequia* Sandy,
Squires, and Demettrion, 1995

Figures 12, 13

LOCAL OCCURRENCE. CSUN locs. 374, 548.

REMARKS. Eighteen specimens are known from the Llajas Formation. Most are from CSUN locality 374, and many are internal molds. The valves are thin and fragile, and they show a very distinctive ornament of broad, nonbifurcating ribs developed anteriorly. The specimens have close affinity to *T. batequia* Sandy, Squires, and Demettrion (1995:50–51, figs. 3.1–3.19, 4.1, 4.2, 5) from the middle Eocene part of the Bateque Formation in Baja California Sur, Mexico. The Llajas specimens differ from *T. batequia* by being larger, rarely (rather than commonly) having the width greater than the length, and not having a broad sulcation (defined by two slightly prominent ribs). In addition, the Llajas specimens do not have the ornament extending as far posteriorly as on some specimens of *T. batequia*.

Phylum Mollusca Linnaeus, 1758

Class Gastropoda Cuvier, 1797

Superorder Caenogastropoda Cox, 1959

Family Strombidae Rafinesque, 1815

Genus *Platyoptera* Conrad, 1854

TYPE SPECIES. *Platyoptera extenta* (Conrad, 1854), by monotypy; upper Eocene, southeastern United States.

Platyoptera pacifica Squires and
Demettrion, 1990a
Figure 14

Platyoptera pacifica Squires and Demettrion, 1990a:
100–102, figs. 2.6, 2.7; Squires and Demettrion,
1992:30–31, fig. 72.

PRIMARY TYPE MATERIAL. IGM holotype 5055 and IGM paratype 5056, both from CSUN locality 1220b, Bateque Formation, Baja California Sur, Mexico.

MOLLUSCAN STAGE RANGE. “Capay” and “Domengine.”

GEOGRAPHIC DISTRIBUTION. Eastern Laguna San Ignacio area, Baja California Sur; San Diego, California, and Simi Valley, California.

LOCAL OCCURRENCE. CSUN loc. 548.

REMARKS. A single specimen is known from the Llajas Formation. Most of the teleoconch is an internal mold, and the wing is preserved as an external mold.

The Llajas Formation occurrence of this species represents the first record of this gastropod in “Domengine Stage” strata. Prior to this study, *P. pacifica* was known only from the “Capay Stage” part of the Bateque Formation in Baja California Sur, Mexico (Squires and Demettrion, 1992).

Family Naticidae Forbes, 1838

Genus *Amaurellina* Fischer, 1885

TYPE SPECIES. *Ampullaria spirata* Lamarck, 1804a, by monotypy; middle Eocene, Paris Basin, France.

Amaurellina caleocia Vokes, 1939

Figure 15

Amauroopsis alveata (Conrad). Dickerson, 1916 [in part]:pl. 38, fig. 7; Anderson and Hanna, 1925: 119–120, pl. 6, fig. 2; pl. 7, fig. 1; pl. 15, fig. 17. Not *Natica alveata* Conrad, 1855a [= *Tejonina moragai* (Stewart, 1927)].

Amaurellina caleocia Vokes, 1939:172–173, pl. 22, figs. 4–6 [new name, in part, for *Amauroopsis alveata* (Conrad) of Dickerson, 1916, preoccupied and misidentified]; Marincovich, 1977:241–243, pl. 20, figs. 11–13; pl. 21, figs. 1, 2; Kappeler et al., 1984:table 2; Squires, 1987:37, fig. 45; 1988b:12–13, fig. 26; 1991:pl. 1, fig. 26.

Amaurellina garzaensis Vokes, 1939:173, pl. 22, figs. 9, 12, 16; Marincovich, 1977:241, pl. 20, fig. 13.

PRIMARY TYPE MATERIAL. UCMP holotype 33781 and UCMP paratype 15862 of *Amaurellina caleocia* Vokes, 1939; both from UCMP locality 672, Domengine Formation, Fresno County, California.

MOLLUSCAN STAGE RANGE. “Capay” and “Domengine.”

GEOGRAPHIC DISTRIBUTION. Orocopia Mountains, Riverside County, California, to Fresno County, California.

LOCAL OCCURRENCE. LACMIP loc. 7418, CSUN loc. 371.

REMARKS. Seven specimens are known from the Lajas Formation. Most are from LACMIP locality 7418. All the specimens are well preserved and show the distinctive spiral ribs.

Superorder Neogastropoda Thiele, 1929

Family Muricidae Rafinesque, 1815

Genus *Pterynotus* Swainson, 1833

TYPE SPECIES. *Murex pinnatus* Swainson, 1822, by subsequent designation (Swainson, 1833); Recent, western Pacific and eastern Indian Ocean.

Subgenus *Pterynotus* s.s.

Pterynotus (*Pterynotus*) cf. *Pterynotus* (*Pterynotus*) *washingtonicus* Squires and Goedert, 1995

Figures 16, 17

LOCAL OCCURRENCE. LACMIP loc. 16654.

REMARKS. A single specimen is known from the Lajas Formation. It is poorly preserved and was reported by Squires and Goedert (1995:266) to be *Pterynotus* (*P.*) sp. indet. The author now con-

siders this specimen tentatively to be *Pterynotus* (*P.*) *washingtonicus* Squires and Goedert, 1995, a species known with certainty only from the transition rocks in the middle Eocene (stage undifferentiated) upper part of the Crescent Formation and lower part of the McIntosh Formation, Lewis County, Washington. The specimen from the Lajas Formation is very close morphologically to *P. (P.) washingtonicus* Squires and Goedert (1995:266–267, figs. 16–18) in having three flanged varices, spiral ribs, and a single intervarical axial rib.

Family Pseudolividae Fischer, 1884

Genus *Calorebama* Squires, 1989

TYPE SPECIES. *Calorebama dilleri* s.s. (Dickerson, 1914), by original designation; lower to middle Eocene, Pacific coast of North America.

Calorebama inornata (Dickerson, 1915)

Figure 18

Pseudoliva inornata Dickerson, 1915:62–63, pl. 7, figs. 1a–1c; Anderson and Hanna, 1925:52, pl. 12, fig. 1; Clark, 1929:pl. 13, fig. 13; Givens, 1974:86, pl. 9, fig. 6.

Pseudoliva tejonensis Dickerson, 1915:63, pl. 7, fig. 2.

Pseudoliva kirby Clark. Weaver, 1943:pl. 89, fig. 7. Not of Clark, 1938.

Calorebama inornata (Dickerson). Squires, 1989: 43–44, figs. 2.13, 2.14; 1994:pl. 1, fig. 3.

PRIMARY TYPE MATERIAL. UCMP holotype 11053, UCMP locality 458, “Tejon Formation,” Kern County, California; CAS paratype 307, CAS locality 183, Cowlitz Formation, Lewis County, Washington.

MOLLUSCAN STAGE RANGE. “Domengine” to “Tejon.”

GEOGRAPHIC DISTRIBUTION. San Diego, California, to southwestern Washington.

LOCAL OCCURRENCE. LACMIP locs. 7434, 7435, 7438, 7445.

REMARKS. Four specimens are known from the Lajas Formation. All are well preserved, except for the specimen from LACMIP locality 7434. Squires (1989) reported *C. inornata* (Dickerson, 1915) as present in the Lajas Formation. Adult specimens of *C. inornata*, like the four found in the Lajas Formation, are characterized by a fusiform shape, very fine spiral ribbing, a rounded body whorl shoulder with no nodes, and a flattened or slightly concave area between the suture and the body whorl shoulder. There is no subsutural swelling on the body whorl shoulder, like that found on most of the other species/subspecies of *Calorebama*. As reported by Squires (1989), the spiral ribbing on *C. inornata* can be very faint, and this is the case for the Lajas specimens. The Lajas specimen illustrated in Figure 18 is nearly smooth and has only extremely faint spiral ribbing.

Vermeij (1998), in his generic revision of family

Pseudolividae, incorporated several genera, including *Calorebama*, into a single genus; namely, *Sulcobuccinum* d'Orbigny, 1847b. In its modified usage by Vermeij, *Sulcobuccinum* has an enormous range in morphology, and the very useful biostratigraphic and paleobiogeographic attributes of the genera incorporated into this genus are negated. Vermeij mentioned that two of the characters of *Calorebama* are not generically diagnostic; namely, spiral structure and a nodose shoulder. He stated that all pseudolivids have spiral sculpture, but, in fact, there are smooth species. An example is *Pseudoliva plumbea* (Dillwyn, 1817), which is the type species of genus *Pseudoliva* Swainson, 1840. In regards to the nodose shoulder, Squires (1989:39) reported that *Calorebama* can have "any combination of subsutural swollen rim, concave ramp, and nodes on the shoulder"; in essence, he stated that the shoulder does not have to be nodose. Vermeij's arguments against the usage of *Calorebama*, therefore, are not valid. The present author recognizes, however, that a cladistic study of all pseudolivine genera is much needed.

In addition, in Vermeij's (1998) treatment of pseudolivids, he also incorporated all species and subspecies of *Calorebama* of the Pacific coast of North America, including *C. inornata*, into a single species; namely, *Sulcobuccinum lineatum* (Gabb, 1864), which in its revised sense, is very highly variable in its morphology. Vermeij did not explain why species of *Calorebama* from the southeastern United States were not included in his revised concept of *S. lineatum*, even though these species are extremely close in morphology to some of the forms he assigned to *S. lineatum*.

Family Mitridae Swainson, 1831

Genus *Mitra* Lamarck, 1798

TYPE SPECIES. *Voluta mitra* Linnaeus, 1758, by tautonymy (ICZN Opinion 885 in 1969); Recent, Indo-Pacific.

Mitra simplicissima Cooper, 1894

Figures 19, 20

Mitra simplicissima Cooper, 1894:45–46, pl. 3, fig. 41; Dickerson, 1915:pl. 11, fig. 12.

PRIMARY TYPE MATERIAL. CAS holotype 14, UCMP locality 2226, probably Ardath Shale, Rose Canyon, San Diego, California.

MOLLUSCAN STAGE RANGE. "Domengine."

GEOGRAPHIC DISTRIBUTION. San Diego and Simi Valley, California.

LOCAL OCCURRENCE. LACMIP locs. 20586, 22371, 26624.

REMARKS. Fifty-one specimens are known from the Lajas Formation. All but three of these are from LACMIP locality 20586. This small species is characterized by a smooth shell, except for fine spiral lirae on the neck, and by four columellar folds.

Family Volutidae Rafinesque, 1815

Genus *Lapparia* Conrad, 1855b

TYPE SPECIES. *Mitra dumosa* Conrad, 1854, by original designation; upper Eocene, Mississippi.

Lapparia eomagna (Vokes, 1939)

Figure 21

?*Voluta eomagna* Vokes, 1939:135–136, pl. 18, fig. 18.

"*Voluta*" *eomagna* Vokes. Givens and Kennedy, 1979:table 1.

PRIMARY TYPE MATERIAL. UCMP holotype 15789, UCMP locality A-973, Domengine Formation, north of Coalinga, California.

MOLLUSCAN STAGE RANGE. "Domengine" and "Transition."

GEOGRAPHIC DISTRIBUTION. San Diego, California, to just north of Coalinga, California.

LOCAL OCCURRENCE. LACMIP loc. 22312.

REMARKS. Three specimens of this large and thick-shelled volutid are known from the Lajas Formation. Two are well preserved, and the third is mostly an internal mold. They all show four folds on the columella, with the anteriormost one narrower and somewhat weaker than the other three, which are all about the same strength. The anteriormost fold does not show up in the apertural view (e.g., Fig. 21), because the fold tends to parallel the margin of the columella.

Givens and Kennedy (1979:tables 1, 3) reported but did not figure "V." *eomagna* from the "Domengine Stage" Ardath Shale and from the "Transition Stage" upper Scripps Formation in San Diego County, California.

The shell of Vokes' (1939) species is medium large, heavy, and (as far as can be ascertained) without spiral sculpture. The width of the shell at the body whorl shoulder and the height of the spire are approximately one-half the total height of the shell, thereby imparting a short fusiform to biconical shape to the shell. In addition to being relatively high, the spire is also relatively wide. The body whorl shoulder has seven to eight conical, horizontally oriented sharp nodes. The outer lip is nonvaricose, and the inner lip is thinly callused with four main columellar folds. The siphonal fasciole is only moderately distinct but is prominently twisted outward.

It is difficult to make a positive generic assignment of Vokes' (1939) species, especially given the lack of protoconch information. Morphologic features such as short fusiform to biconical shell shape, sharp and horizontally directed nodes, number and relative strength of the columellar folds, and nonvaricose outer lip all indicate that "V." *eomagna* is more closely related to *Lapparia*, than to *Voluta* Linnaeus, 1758. In fact, Vokes' (1938) species is similar enough to *Lapparia dumosa* (Conrad, 1854:289, pl. 15, fig. 4; Harris and Palmer, 1947:pl. 56, figs. 1–4, 9–10, 21), the type species

of this genus, to warrant provisionally placing Vokes' (1938) species in *Lapparia*. Assignment is provisional because of lack of information about the protoconch of Vokes' (1938) species, and because the shell appears to have no spiral sculpture, which is a characteristic of *Lapparia*. The apparent lack of spiral sculpture on *L. eomagna*, however, might be a function of preservation.

Lapparia is best known from middle to upper Eocene rocks along the Gulf Coastal Plain, extending from Texas to Florida (Palmer and Brann, 1966). Stenzel and Turner (1940) were the first to report *Lapparia* from the Eocene rock record of the Pacific coast of North America when they mentioned that *Voluta martini* Dickerson (1915:76, pl. 11, figs. 14a, 14b), known from "Tejon Stage" rocks of the Tejon Formation in the Tehachapi Mountains at the south end of the San Joaquin Valley, south-central California, should probably be placed in *Lapparia*. They were tentative in their assignment because no information was known about the protoconch of *Lapparia martini*.

Based on a review of the literature, as well as on comments from C. R. Givens (personal communication), two other species of volutid gastropods from the Eocene rock record of the Pacific coast of North America can also be provisionally assigned to *Lapparia*. One of these is *Lapparia coquillensis* (Turner, 1938:73, pl. 18, fig. 12) from the "Capay Stage" informal White Tail Ridge formation of south-western Oregon. The other species is *Lapparia kirbyi* (Merriam and Turner, 1937:103, pl. 5, figs. 3, 4), from the "Capay Stage" Formation of northern California.

Lapparia eomagna is more similar to *L. coquillensis* than it is to the other Pacific coast species of *Lapparia*. *Lapparia eomagna* differs from *L. coquillensis* by having the siphonal fasciole turned outward rather than inward, a carina on the body whorl shoulder, less swollen nodes, and less elongate nodes on the body whorl.

Gulf Coast species of *Lapparia* are characterized by spiral ribbing, which can be faint to moderately strong. Although Pacific coast species of *Lapparia* usually do not show spiral ribbing, some well-preserved specimens show faint indications of spiral ornament (Givens, personal communication).

With further work and more collecting, it might be shown eventually that *L. eomagna*, as well as the other species of Pacific coast *Lapparia*, belong to a new subgenus of *Lapparia* or even to a new genus.

Family Turridae Swainson, 1840

Genus *Cochlespiropsis* Casey, 1904

TYPE SPECIES. *Pleurotoma engonata* Conrad, 1865, by subsequent designation (Cossmann, 1906); middle Eocene (Claiborne Stage), southeastern United States. See MacNeil and Dockery (1984:194) for a detailed analysis of the rather confusing taxonomic history of this species.

?*Cochlespiropsis jenkinsi* new species

Figures 22, 23

DIAGNOSIS. *Cochlespiropsis*-like with a deep anal sinus occupying about the anterior half of the concave ramp, and fine spiral lirae only anterior to the medial angulation on the body whorl.

DESCRIPTION. Medium size, tall, narrowly biconic, turreted, and thick shelled. Adult whorls sharply medially carinate and generally smoothish, with very weak spiral threads anterior to the medial angulation on the body whorl and on the neck. Anal sinus is U-shaped and deep and occupies the anterior half of the concave shoulder ramp (slope). Anal sinus is broadly rounded at its apex; anterior margin of anal sinus coincident with the somewhat rounded medial angulation.

COMPARISON. The new species is very similar to *Cochlespiropsis engonata* (Conrad, 1865), the only known species in *Cochlespiropsis*. Conrad's species has been reported (Toulmin, 1977; Dockery, 1980) from middle Eocene (Claiborne Stage) strata of Texas, Mississippi, and Alabama. The similarity between the new species and a specimen of *C. engonata* illustrated by Powell (1969:410, pl. 321) is especially close, in terms of the narrowly biconic shape, tall spire, medially carinate whorls, overall position of the anal sinus, and generally subdued ornamentation. The Lajas specimens differ from *C. engonata* (Conrad, 1865:210, pl. 21, fig. 12; Harris, 1937:62-63, pl. 11, figs. 11-15; Powell, 1966:42, pl. 5, fig. 7; 1969:410, pl. 321; Toulmin, 1977:280, pl. 46, fig. 7; Dockery, 1980:134, pl. 18, fig. 8) in being larger and thicker shelled, having a deeper and narrower anal sinus whose apex is much closer to the medial angulation, and having fine spiral lirae only anterior to the medial angulation. In spite of their close similarity to the type species of genus *Cochlespiropsis*, the Lajas specimens cannot be assigned with certainty to this genus, because the critically important anterior canal is not present on any of the Lajas material. *Cochlespiropsis* is characterized, in part, by its twisted anterior canal and associated siphonal fasciole.

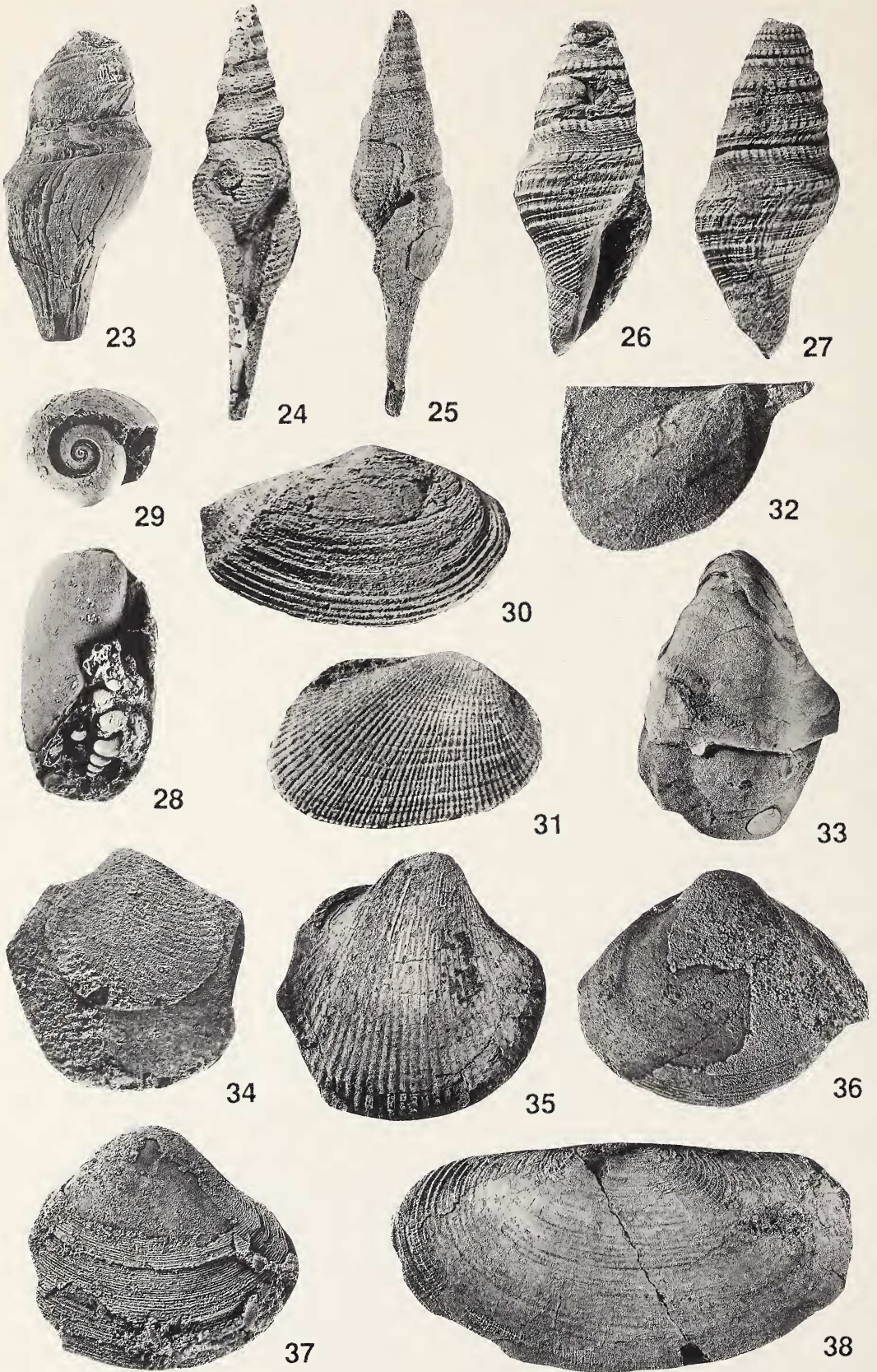
The new species is similar to a variety of "*Turricula*" *transversaria* (Lamarck, 1804b), from upper Eocene (Bartonian Stage) strata of the Paris Basin, France. Cossmann and Pissarro (1910-1913:pl. 50, fig. 223 bis-1') illustrated this variety of Lamarck's species, and the new species differs from it by having much finer spiral ribs but no spiral ribs on either the spire or on the shoulder ramp and having a slightly narrower body whorl.

HOLOTYPE DIMENSIONS. Height 32.5 mm (incomplete), width 15.3 mm.

PRIMARY TYPE MATERIAL. LACMIP holotype 12741, LACMIP locality 22312, and LACMIP paratype 12742, CSUN locality 371.

MOLLUSCAN STAGE RANGE. "Domengine."

GEOGRAPHIC DISTRIBUTION. Simi Valley, California.



LOCAL OCCURRENCE. LACMIP loc. 22312, CSUN loc. 371.

REMARKS. Two specimens are known from the Llajas Formation. They are moderately well preserved, but both are missing their apices and anterior ends; therefore, as discussed above, they can only be tentatively assigned to *Cochlespiropsis*. If the Llajas specimens do belong to this genus, then they would be the first record of *Cochlespiropsis* on the Pacific coast of North America.

ETYMOLOGY. The new species is named for Father Floyd Jenkins, Jesuit Order, who found the paratype and who generously donated that specimen, as well as other megafossils from the Llajas Formation.

Genus *Eosurcula* Casey, 1904

TYPE SPECIES. *Pleurotoma moorei* Gabb, 1860, by subsequent designation (Vokes, 1939); middle Eocene (Claibornian Stage), Texas.

Eosurcula aff. *Eosurcula inconstans* (Cooper, 1894)

Figures 24, 25

LOCAL OCCURRENCE. LACMIP loc. 7434.

REMARKS. A single specimen is known from the Llajas Formation. It is mostly complete, including its delicate, slightly recurved and long anterior canal, but the sculpture is worn, especially on the upper spire. The Llajas specimen is similar to *Protosurcula* Casey, 1904, and to *Plentaria* Harris, 1937. These genera can be distinguished from *Eosurcula* on the basis of the protoconchs, but the protoconch is missing on the Llajas specimen. *Protosurcula* has an almost complete absence of axial sculpture (Powell, 1966), whereas the Llajas specimen has axial sculpture (albeit very worn) on the upper spire. *Plentaria* has a single strong fold, plus one or two weak ones, on the columella (Powell, 1966), whereas the Llajas specimen has a smooth columella. For these reasons, the Llajas specimen is assigned to *Eosurcula*.

The Llajas specimen shows affinity to *Eosurcula inconstans* (Cooper, 1894:40, pl. 2, figs. 20, 21), known only from Eocene rocks at Sutter Buttes,

Sutter County, California. Ramirez (1992) assigned these rocks to the Capay Formation, which is a rock unit known elsewhere as being of early Eocene ("Capay Stage") age (Redwine, 1984). The Llajas specimen differs from *E. inconstans* by being twice as large and by having coarser spiral ribs on the concave ramp posterior to the medial angulation, as well as having no secondary ribs between these particular spiral ribs. Furthermore, the Llajas specimen has very low axial nodes on the upper spire whorls, whereas on *E. inconstans* axial nodes are only present near the apex of the shell. Because of the worn condition of the Llajas specimen, the axial nodes are barely perceptible and occur as vague swellings that cannot be photographed. They are present on the subsutural spiral rib (i.e., immediately anterior to the suture) and on the upper spire whorls. There are also small beads on faint spiral ribs located on the concave slope between the subsutural rib and the medial angulation. The subsutural spiral rib and the small beads are obsolete on the postantepenultimate whorls. The comparison between the Llajas specimen and the syntypes (CAS 68035.01 and 68035.02, both from CAS loc. 68035) of *E. inconstans* is also hampered by the fact that they are incomplete specimens showing only the upper spire. One of the syntypes (CAS 68035.01), which was illustrated by Cooper (1894:fig. 20), had its body whorl and long anterior canal intact. Both are no longer present on the specimen.

Both Cooper's (1894) species (originally identified as *Surcula inconstans*) and the Llajas specimen are herein assigned to genus *Eosurcula* based on characters listed by Powell (1966) as diagnostic of this genus. These characters are the medially angulate whorls, possible axial sculpture, narrow body whorl, long and straight anterior canal, strongest spiral sculpture anterior to the medial angulation, and a U-shaped anal sinus occupying the concave ramp.

Dickerson (1913:276, pl. 11, fig. 5) also reported Cooper's (1894) species as *Turris inconstans* (Cooper) from the Sutter Buttes area, but Anderson and Hanna (1925:94-95) reported that Dickerson's

Figures 23-38 Gastropods and bivalves from the Llajas Formation. All specimens coated with ammonium chloride. 23-29. Gastropods. 23. ?*Cochlespiropsis jenkinsi* n. sp., left-lateral view, $\times 1.6$, LACMIP paratype 12742, CSUN loc. 371. 24, 25. *Eosurcula* aff. *Eosurcula inconstans* (Cooper, 1894), $\times 1.4$, LACMIP hypotype 12743, LACMIP loc. 7434. 24. Apertural view. 25. Right-lateral view. 26, 27. *Bathytoma pacifica* n. sp., $\times 3.4$, LACMIP holotype 12744, LACMIP loc. 22371. 26. Apertural view. 27. Abapertural view. 28, 29. *Akera maga* Vokes, 1939, $\times 2$, LACMIP hypotype 12746, LACMIP loc. 26624. 28. Apertural view. 29. Apical view. 30-38. Bivalves. 30. ?*Hilgardia parkei* (Anderson and Hanna, 1925), right valve, $\times 6.1$, LACMIP hypotype 12747, LACMIP loc. 26624. 31. *Barbatia* sp., right valve, $\times 10.8$, LACMIP hypotype 12748, LACMIP loc. 25837. 32. *Pteria pellucida* (Gabb, 1864), right valve, $\times 2.6$, LACMIP hypotype 12749, CSUN loc. 548. 33. *Pycnodonte* (*Phygraea*) cf. *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demetron, 1990b, right valve, $\times 0.9$, LACMIP hypotype 12750, LACMIP loc. 7405. 34. *Divaricella cumulata* (Gabb, 1864), right valve, $\times 3.9$, LACMIP hypotype 12751, LACMIP loc. 7430. 35. *Acanthocardia* (*Agnocardia*) *sorrentoensis* (Hanna, 1927), right valve, $\times 1.1$, LACMIP hypotype 12752, LACMIP loc. 22312. 36, 37. ?*Mactromeris merriami* (Packard, 1916), LACMIP loc. 26617. 36. Left valve, $\times 2.9$, LACMIP hypotype 12753. 37. Right valve, $\times 2$, LACMIP hypotype 12754. 38. *Gari texta* Gabb, 1864, left valve, $\times 1.3$, LACMIP hypotype 12755, CSUN loc. 374

specimen was actually *Gemmula wattsi* Anderson and Hanna, 1925.

Eosurcula has been reported previously from the Paleogene rock record of the Pacific coast of North America. Vokes (1939) reported *E. capayana* Vokes (1939:118–119, pl. 17, figs. 12, 13) from rocks that Squires (1988c) assigned to the Cerros Shale Member (“Capay Stage”) of the Lodo Formation, north of Coalinga, California. Givens (1974) also reported *E. capayana* from the “Capay Stage” Juncal Formation in the Pine Mountain area, Ventura County, California. The Llajas specimen of *Eosurcula* aff. *E. inconstans* differs significantly from *E. capayana* by not having three prominent and equally spaced primary carinae on the body whorl and not having two primary spiral ribs on the spire whorls.

Givens and Kennedy (1979) taxonomically revised the two following turrid species and placed them in *Eosurcula*: *E. preattenuata* (Gabb, 1869) and *E. cohnii* (Dickerson, 1915). The Llajas specimen of *Eosurcula* aff. *E. inconstans* differs from *E. preattenuata* (Gabb, 1869:150, pl. 26, fig. 27; Hanna, 1927:326, pl. 54, figs. 2, 7, 9, 10), known from the “Domengine Stage” Ardath Shale and possibly from the “Transition Stage” Scripps Formation in the San Diego, California, area by having a much longer anterior canal and by having much less prominent nodes on the medial angulation area. The Llajas specimen of *Eosurcula* aff. *E. inconstans* differs from *E. cohnii* (Dickerson, 1915:70, pl. 10, fig. 1), known from Eocene strata in Grapevine Canyon of Kern County, California, by having finer spiral ribs on the ramp and by having much less prominent nodes on the medial angulation.

Genus *Bathytoma* Harris and Burrows, 1891

TYPE SPECIES. *Murex cataphractus* Brocchi, 1814, by monotypy; late Miocene to Pliocene, northern Italy.

Bathytoma pacifica new species

Figures 26, 27

DIAGNOSIS. A *Bathytoma* with a broad concave area between the two main carinae and weak nodes on body whorl shoulder.

DESCRIPTION. Small, solid, biconical. Spire whorls with closely spaced spiral threads overridden by axial growth lines causing spirals to be beaded. Spire whorls with two prominent carinae (separated by a broad concave slope) and a beaded carina just posterior to the suture. Posterior carina passes into a subsutural collar and the nodes on the anterior carina become much weaker. Body whorl region anterior to the periphery with alternating strong and weaker spiral ribs, becoming more closely spaced on neck area. Anal sinus moderately broad, open V-shape with a narrow U-shape at the apex, which is on the peripheral carina and to a slight distance posteriorly. Columella smooth, with a moderate callus; siphonal fasciole well developed; anterior canal moderately short.

COMPARISON. The new species is assigned to *Bathytoma* based on the biconical shape, whorls concave posteriorly, beaded spiral ribs, anal sinus on the peripheral carina, and short anterior canal with a siphonal fasciole. The new species is most similar to *Bathytoma* cf. *B. nonplicata* Harris, 1937, illustrated by Garvie (1996:99–100, pl. 20, figs. 4, 5) from the lower Eocene (lower Claibornian Stage) Marquez Shale Member of the Reklaw Formation in east and central Texas. The new species differs by having a broader concave area between the two main carinae on the spire whorls, much weaker nodes on the anterior carina, and spiral ribs more widely spaced on the anterior part of the body whorl.

Bathytoma usually bears a distinct, submedial fold on the columella, but the presence of this fold is not a constant feature (Powell, 1966; Garvie, 1996). *Bathytoma* cf. *B. nonplicata*, for example, has a smooth columella, as does the new species.

The new species also resembles *Bathytoma turbida* (Solander, 1766) from upper Eocene (Bartonian Stage) strata in the Anglo-Paris basin, and Cossmann and Pissarro (1910–1913:pl. 50, fig. 221-1) illustrated this species. *Bathytoma pacifica* n. sp. differs by having a narrower shell, a broader concave area between the two main carinae on the spire whorls, much weaker nodes on the anterior carina (especially on the body whorl), and much finer spiral ribs on the anterior part of the body whorl. Some specimens of *B. turbida* from the author’s private collection of material from Barton-on-Sea, southern England, are like *B. pacifica* n. sp., in that the columella is smooth, but some of the other Barton-on-Sea specimens have a fold on the columella.

Waring (1917:81–82) reported *Bathytoma boundeyi* Waring, 1917, from the upper Paleocene Santa Susana Formation on the south side of Simi Valley, but Squires (2000) showed that Waring’s species does not have the morphologic features characteristic of genus *Bathytoma* and that this species actually belongs in genus *Parasyrinx* Finlay, 1924. Squires (2000) also showed that *Parasyrinx boundeyi* (Waring) is the senior synonym of *Parasyrinx hickmani* Zinsmeister, 1983, which is known only from the Santa Susana Formation on the south side of Simi Valley (Zinsmeister, 1983:1300–1301, figs. 3V, 3W).

HOLOTYPE DIMENSIONS. Height 16 mm (uppermost spire missing), width 7 mm.

PRIMARY TYPE MATERIAL. LACMIP holotype 12744 and paratype 12745; both from LACMIP locality 22371.

MOLLUSCAN STAGE RANGE. “Domengine.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, California.

LOCAL OCCURRENCE. LACMIP loc. 22371.

REMARKS. Two specimens are known from the Llajas Formation, and both are missing their uppermost spire.

Bathytoma is widely represented in the Eocene

of the southern United States and in the Eocene of the Anglo-Paris basin in Europe. Today, the genus is confined to deep water in the Caribbean (Garvie, 1996). The new species is the first report of *Bathytoma* in the fossil record of California.

ETYMOLOGY. The new species is named for the Pacific Ocean.

Subclass Heterobranchia Gray, 1840

Family Akeridae Pilsbry, 1893

Genus *Akera* Müller, 1776

TYPE SPECIES. *Akera bullata* Müller, 1776, by original designation; Recent, Denmark.

Akera maga Vokes, 1939

Figures 28, 29

Akera maga Vokes, 1939:111, pl. 16, figs. 34, 40, 41; Givens, 1974:93.

PRIMARY TYPE MATERIAL. UCMP holotype 15761, UCMP locality A-1281; UCMP paratype 15752, UCMP locality A-976; both from Domingine Formation, south of Coalinga, Kings County, California.

MOLLUSCAN STAGE RANGE. "Capay" and "Domengine."

GEOGRAPHIC DISTRIBUTION. Simi Valley and Pine Mountain area, Ventura County, California, and near Coalinga, Fresno County, California.

LOCAL OCCURRENCE. LACMIP locs. 22312, 26624.

REMARKS. Four specimens are known from the Lajas Formation. All are internal molds. One specimen is from LACMIP locality 22312, and three specimens are from LACMIP locality 26624. Genus *Akera* is characterized by its deeply channeled suture.

Class Bivalvia Linnaeus, 1758

Order Nuculoida Dall, 1889

Family Nuculanidae H. Adams and A. Adams, 1858

Genus *Hilgardia* Harris and Palmer, 1946

TYPE SPECIES. *Leda multilineata* Conrad, 1855, by original designation; Eocene, Gulf Coast.

?*Hilgardia parkei* (Anderson and Hanna, 1925)

Figure 30

Leda parkei Anderson and Hanna, 1925:179–180, pl. 2, figs. 10, 11; Hanna, 1927:270.

Nuculana (Saccella) parkei (Anderson and Hanna). Givens, 1974:39.

?*Hilgardia parkei* (Anderson and Hanna). Moore, 1983:A22–A23, pl. 3, figs. 6, 7; Squires, 1987: 54–55, fig. 87.

PRIMARY TYPE MATERIAL. CAS holotype

782, CAS locality 244, "Tejon Formation," Kern County, California.

MOLLUSCAN STAGE RANGE. "Capay" to "Tejon."

GEOGRAPHIC DISTRIBUTION. San Diego, San Diego County to Tehachapi Mountains, Kern County, California.

LOCAL OCCURRENCE. LACMIP loc. 26624.

REMARKS. A single specimen is known from the Lajas Formation. It is a partially weathered right valve, and the nodes along the posterior umbonal ridges have been obscured. This species is characterized by having distinct concentric sculpture and having an impressed area on the posterior dorsal slope with an intercalated umbonal ridge between two stronger umbonal ridges.

Order Arcoida Stoliczka, 1871

Family Arcidae Lamarck, 1809

Genus *Barbatia* Gray, 1842

TYPE SPECIES. *Arca barbata* Linnaeus, 1758, by subsequent designation (Gray, 1857); Recent, Mediterranean Sea.

Subgenus *Barbatia* s.s.

Barbatia sp.

Figure 31

LOCAL OCCURRENCE. LACMIP loc. 25837.

REMARKS. A single specimen is known from the Lajas Formation. It is an early juvenile (3.5 mm long), and it is a well-preserved right valve. Because of its early stage of growth, it is difficult to assign this specimen to a species. It is most similar to *Barbatia (Barbatia) suzsalloi* (Weaver and Palmer, 1922) from the Cowlitz Formation, southwestern Washington. Nesbitt (1995) reported the geologic age of the Cowlitz Formation to be late middle Eocene, which is equivalent to the upper part of the "Tejon Stage." The Lajas specimen differs from *B. (B.) suzsalloi* (Weaver and Palmer, 1922:8–9, pl. 8, fig. 6; Weaver, 1943:68, pl. 11, fig. 7; pl. 12, fig. 10; Reinhart, 1943:29, pl. 1, figs. 14–16) by having radial ribs that are unbeaded, bifurcate about half way down from the umbo to the ventral margin, and bifurcate only in the medial part of the valve.

Family Pteriidae Gray, 1847b

Genus *Pteria* Scopoli, 1777

TYPE SPECIES. *Mytilus hirundo* Linnaeus, 1758, by original designation; Recent, Mediterranean Sea.

Pteria pellucida (Gabb, 1864)

Figure 32

Avicula pellucida Gabb, 1864:186–187, pl. 25, fig. 172.

Pteria pellucida (Gabb). Vokes, 1939:50–51, pl. 2, figs. 1, 4, 7, 8; Weaver and Kleinpell, 1963:197,

pl. 29, fig. 5; Givens, 1974:43, pl. 1, fig. 10; Moore, 1983:A82, pl. 24, fig. 3.
Not *Pteria pellucida* (Gabb). Anderson and Hanna, 1925:188–189, pl. 1, fig. 1.

PRIMARY TYPE MATERIAL. UCMP lectotype 11983 and UCMP lectoparatype 15576, both designated by Vokes (1939:50); all types probably from Domengine Formation near Martinez, Contra Costa County, California.

MOLLUSCAN STAGE RANGE. “Domengine” through upper Eocene *Turritella schencki delagueræ* Zone of Weaver and Kleinpell (1963).

GEOGRAPHIC DISTRIBUTION. Simi Valley, Ventura County to Contra Costa County, California.

LOCAL OCCURRENCE. CSUN loc. 548.

REMARKS. Ten specimens are known from the Lajas Formation. All but one of the specimens are external molds of unbroken single valves. The only specimen that has shell material adhering is a broken single valve. The Lajas Formation record of this species is the farthest south it has been reported, although it has been reported (Weaver and Kleinpell, 1963; Givens, 1974) elsewhere in southern California.

Order Ostreoida Férussac, 1822

Family Gryphaeidae Vyalov, 1936

Genus *Pycnodonte* Fischer, 1835

TYPE SPECIES. *Pycnodonte radiata* Fischer, 1835, by original designation; Late Cretaceous, Crimea.

Subgenus *Phygraea* Vyalov, 1936

TYPE SPECIES. *Gryphaea* (*Gryphaea*) sec. *Phygraea frauscheri* Vyalov, 1936, by original designation; late Paleocene, Austria.

Pycnodonte (*Phygraea*) cf. *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demettrion, 1990b
Figure 33

LOCAL OCCURRENCE. LACMIP locs. 7405, 22312, and an inexactly known locality in the vicinity of LACMIP loc. 7434.

REMARKS. Only single specimens of the right (upper valve) are known from LACMIP localities 7405 and 22321. The specimens, which are fragments, show a partial wing-like extension separated from the main part of the valve by a moderately shallow radial sulcus. Two large but incomplete valves are known from the inexactly known locality in the vicinity of LACMIP locality 7434. One of these valves is a flat right valve, and the other valve is a strongly convex left valve. None of the specimens from the Lajas Formation shows the hinge line or the valve interiors. The Lajas specimens are tentatively identified as *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demettrion, 1990b, known from

the “Capay Stage” through lower middle part of the “Tejon Stage” in the Bateque Formation in Baja California Sur, Mexico. The Lajas specimens are the second record of *Pycnodonte* (*Phygraea*) in the rock record of California. *Pycnodonte* (*Phygraea*) cf. *Pycnodonte* (*P.*) *pacifica* was reported from “Meganos Stage” rocks in the upper 100 m of the Santa Susana Formation in Simi Valley (Squires, in press).

Order Veneroida H. Adams and
A. Adams, 1856

Family Lucinidae Fleming, 1828

Genus *Divaricella* Martens, 1880

TYPE SPECIES. *Divaricella angulifera* Martens, 1880, by original designation; Recent, Indian Ocean (Mauritius).

Divaricella cumulata (Gabb, 1864)
Figure 34

Lucina cumulata Gabb, 1864:176, pl. 24, fig. 254; Dickerson, 1915:80, pl. 2, fig. 4.

“*Lucina*” *cumulata* (Gabb). Stewart, 1930:188.
Not *Phacoides cumulata* (Gabb). Arnold and Anderson, 1907:130, pl. 14, fig. 2.

Divaricella cumulata (Gabb). Anderson and Hanna, 1925:171. Deméré et al., 1979:pl. 2, fig. 9.
? *Divaricella*? (*Egracina*) *cumulata* (Gabb). Moore, 1988:D22, pl. 7, figs. 5, 6.

PRIMARY TYPE MATERIAL. UCMP holotype 11988, “Tejon Formation,” Kern County, California.

MOLLUSCAN STAGE RANGE. “Domengine” through middle part of “Tejon.”

GEOGRAPHIC DISTRIBUTION. San Diego, southern California, to southwestern Washington.

LOCAL OCCURRENCE. LACMIP loc. 7430.

REMARKS. A single specimen is known from the Lajas Formation. It is a single valve that shows the diagnostic divaricate sculpture. Although the hinge is very poorly preserved, there is a mold of a cardinal tooth present.

During the course of this research, the author came across two specimens of *Divaricella cumulata* from Eocene strata in southwestern Washington. One is from CSUN locality 1573 in the transition zone of interbedded volcanic and sedimentary rocks between the upper Crescent Formation and the overlying lower member of the McIntosh Formation. Squires and Godert (1995) assigned these rocks to the middle Eocene (undifferentiated stage). The other specimen is from LACMIP locality 22536 in the Cowlitz Formation (upper part of “Tejon Stage”). These two specimens significantly extend the geographic range of this species, which prior to this report was known only from middle Eocene strata of southern California.

Family Cardiidae Lamarck, 1809

Genus *Acanthocardia* Gray, 1851

TYPE SPECIES. *Cardium aculeatum* Linnaeus, 1758, by subsequent designation (Stoliczka, 1870); Recent, Mediterranean Sea.

Subgenus *Agnocardia* Stewart, 1930

TYPE SPECIES. *Cardium (Trachycardium) clai-bornense* Aldrich, 1911, by original designation; Eocene (Claibornian Stage), Mississippi.

Acanthocardia (Agnocardia) sorrentoensis
(Hanna, 1927)

Figure 35

Cardium sorrentoensis Hanna, 1927:285–286, pl. 41, figs. 10, 12, 14; Clark, 1929:pl. 6, fig. 1.

Trachycardium (Agnocardia) sorrentoensis (Hanna). Stewart, 1930:265; Vokes, 1939:76.

Acanthocardia (Agnocardia) sorrentoensis (Hanna). Moore, 1998:2–3, pl. 4, fig. 5.

PRIMARY TYPE MATERIAL. UCMP holotype 31000, UCMP locality 3975, probably Ardath Shale, Rose Canyon, San Diego County, California; UCMP paratype 31001, UCMP locality 5059, probably Ardath Shale, Rose Canyon, San Diego County, California; and UCMP paratype 31002, UCMP locality 5062, probably Delmar Formation, Torrey Pines State Reserve, San Diego County, California.

MOLLUSCAN STAGE RANGE. “Domengine.”

GEOGRAPHIC DISTRIBUTION. San Diego, San Diego County, to Contra Costa County, California.

LOCAL OCCURRENCE. LACMIP loc. 22312.

REMARKS. Eight specimens are known from the Lajas Formation. Most of them are internal molds or have badly weathered shells with only thin remnants of shell. The node-like spines that are one of the characters of this species, therefore, are not present.

Vokes (1939:table 3) reported this cardiid bivalve species from the Lajas Formation, but he did not cite any catalog-numbered specimens, nor did he give any locality information.

Moore (1998) reported that *Acanthocardia (Agnocardia) sorrentoensis* occurs in the “Paleocene” Cerros Shale Member of the Lodo Formation and in Eocene strata in the San Diego area. She stated that the Cerros Shale Member occurrence was based on Vokes’s (1939) work. Vokes (1939:table 3), however, listed this bivalve only from “Domengine Stage” strata in California, as far north as Mount Diablo, Contra Costa County.

Family Mactridae Lamarck, 1809

Genus *Mactromeris* Conrad, 1868

TYPE SPECIES. *Mactra ovalis* Gould, 1840, by subsequent designation (Stoliczka, 1871); Recent, New England.

?*Mactromeris merriami* (Packard, 1916)

Figures 36, 37

Spisula merriami Packard, 1916:294–295, pl. 27, figs. 3–4; Dickerson, 1916:485–486, pl. 39, figs. 2a–2c, not 2d; Vokes, 1939:97, pl. 15, figs. 12, 13; Weaver, 1943:233–234, pl. 52, figs. 11, 12; p. 54, fig. 10; Stewart, 1946:pl. 11, fig. 23; Squires, 1987:67, fig. 114.

Spisula cf. merriami Packard. Turner, 1938:64, pl. 6, fig. 12.

Mactromeris? merriami (Packard). Moore, 1998:21–22, pl. 11, figs. 1, 2, 5, 7.

PRIMARY TYPE MATERIAL. UCMP holotype 11484, UCMP paratype 11485, UCMP locality 672, Domengine Formation, Fresno County, California.

MOLLUSCAN STAGE RANGE. “Domengine.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, southern California, to southwestern Oregon.

LOCAL OCCURRENCE. LACMIP loc. 26617.

REMARKS. Four specimens are known from the Lajas Formation. They are poorly preserved single valves, whose shells are mostly missing, except along the margins of the valves. ?*Mactromeris merriami* (Packard, 1916:294–295, pl. 27, figs. 3, 4) shows considerable variation in the strength of the concentric ribbing on the central surface of the shell. This report uses the recent taxonomic work of Moore (1998), who tentatively assigned Packard’s species to genus *Mactromeris*.

Family Psammobiinae Fleming, 1828

Genus *Gari* Schumacher, 1817

TYPE SPECIES. *Gari vulgaris* Schumacher, 1817, subsequent designation (ICZN Opinion 910 in 1970); Recent, Indo-Pacific.

Gari texta Gabb, 1864

Figure 38

?*Gari texta* Gabb, 1864:155, pl. 22, fig. 130.

“*Gari*” *texta* Gabb. Stewart, 1930:283, pl. 7, fig. 12.

Gari texta Vokes, 1939:93, pl. 15, fig. 1; Squires, 1987:fig. 68, fig. 117.

Gari cf. G. eoundulata Vokes. Squires, 1984:50, fig. 12f.

PRIMARY TYPE MATERIAL. USNM holotype 4471, “Domengine sandstone” near Martinez, Contra Costa County, California.

MOLLUSCAN STAGE RANGE. “Domengine.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, to Contra Costa County, California.

LOCAL OCCURRENCE. LACMIP loc. 22371, CSUN locs. 374, 548.

REMARKS. Four specimens are known from the Lajas Formation. Two are from CSUN locality 374. One of these is a closed valved and is mostly an internal mold with some shell adhering to the margins of the valves. The other specimen from this

locality is a single valve with most of its shell intact. On both of these specimens, where the shell is present, there are minute radial ribs that are so characteristic of this species. A single, closed-valved specimen of an internal mold is from LACMIP locality 22371. A single specimen is from CSUN locality 548, and it is a "butterflied" external mold and its corresponding internal mold. The external mold shows the characteristic radial ribbing.

Vokes (1939:93, pl. 15, fig. 1) figured a specimen of *Gari texta* from LACMIP locality 22312 [= UCMP locality 7004]. Although LACMIP locality 22312 is in the Llajas Formation, he never mentioned the Llajas Formation by name, and so the reference to this formation is extremely subtle. *Gari texta* is included in this report in order to bring proper attention to the presence of this species in the Llajas Formation.

Internal molds of *Gari texta* look very much like *G. eoundulata* Vokes, 1939, from the Arroyo Hondo Formation in central California because the molds show only undulating concentric bands without any radial ribs. *Gari eoundulata* Vokes (1939:93-94, pl.14, figs. 23, 24) differs from *G. texta* by being smooth and by having a distinct posterior umbonal groove and a well-developed ridge dorsal to it. Laiming (1940:fig. 4) regarded the "Arroyo Hondo Formation" to be the upper member ("Capay Stage") of the Lodo Formation.

Family Veneridae H. Adams
and A. Adams, 1856

Genus *Pitar* Römer, 1857

TYPE SPECIES. *Venus tumens* Gmelin, 1791, by monotypy; Recent, West Africa.

Pitar uvasana coquillensis Turner, 1938
Figures 39, 40

Pitar uvasana coquillensis Turner, 1938:54, pl. 11,
figs. 14-17.

PRIMARY TYPE MATERIAL. UCMP holotype 33076, UCMP locality A-836; UCMP paratypes 33077-33078, UCMP locality A-838; all probably from the informally named White Tail Ridge formation, Middle Fork Coquille River, Coos County, Oregon.

MOLLUSCAN RANGE. "Meganos" through "Domengine."

GEOGRAPHIC OCCURRENCE. Simi Valley, California, to Coos County, Oregon.

LOCAL OCCURRENCE. CSUN loc. 374.

REMARKS. Five specimens are known from the Llajas Formation. All are from the "Stewart bed." One specimen is a closed valved with about half of its shell material intact. The other specimens are badly weathered, but two show the hinge line.

Turner (1938:54) reported an unnamed form from the "Stewart bed" at CSUN locality 374 [= UCMP locality 7004] that is closely related to *Pitar uvasana coquillensis*. Unfortunately, he did not give the specimens museum catalog numbers. It would seem, however, that this form is represented by the specimens used in this study. The Llajas specimens represent the first occurrence of *Pitar uvasana coquillensis* in "Domengine Stage" strata.

Order Myoida Stoliczka, 1870

Family Gastrochaenidae Gray, 1840

Genus *Gastrochaena* Spengler, 1783

TYPE SPECIES. *Gastrochaena cuneiformis* Spengler, 1783, by subsequent designation (Children, 1822); Recent, Philippines.

Gastrochaena ?dubitata Hanna, 1927
Figures 41, 42

Gastrochaena dubitata Hanna, 1927:298, pl. 45,
figs. 1, 2, 3, 5).

PRIMARY TYPE MATERIAL. UCMP holotype 31149, UCMP locality 5062, probably Delmar Formation, Torrey Pines State Reserve, San Diego, California.

MOLLUSCAN STAGE RANGE. "Domengine."

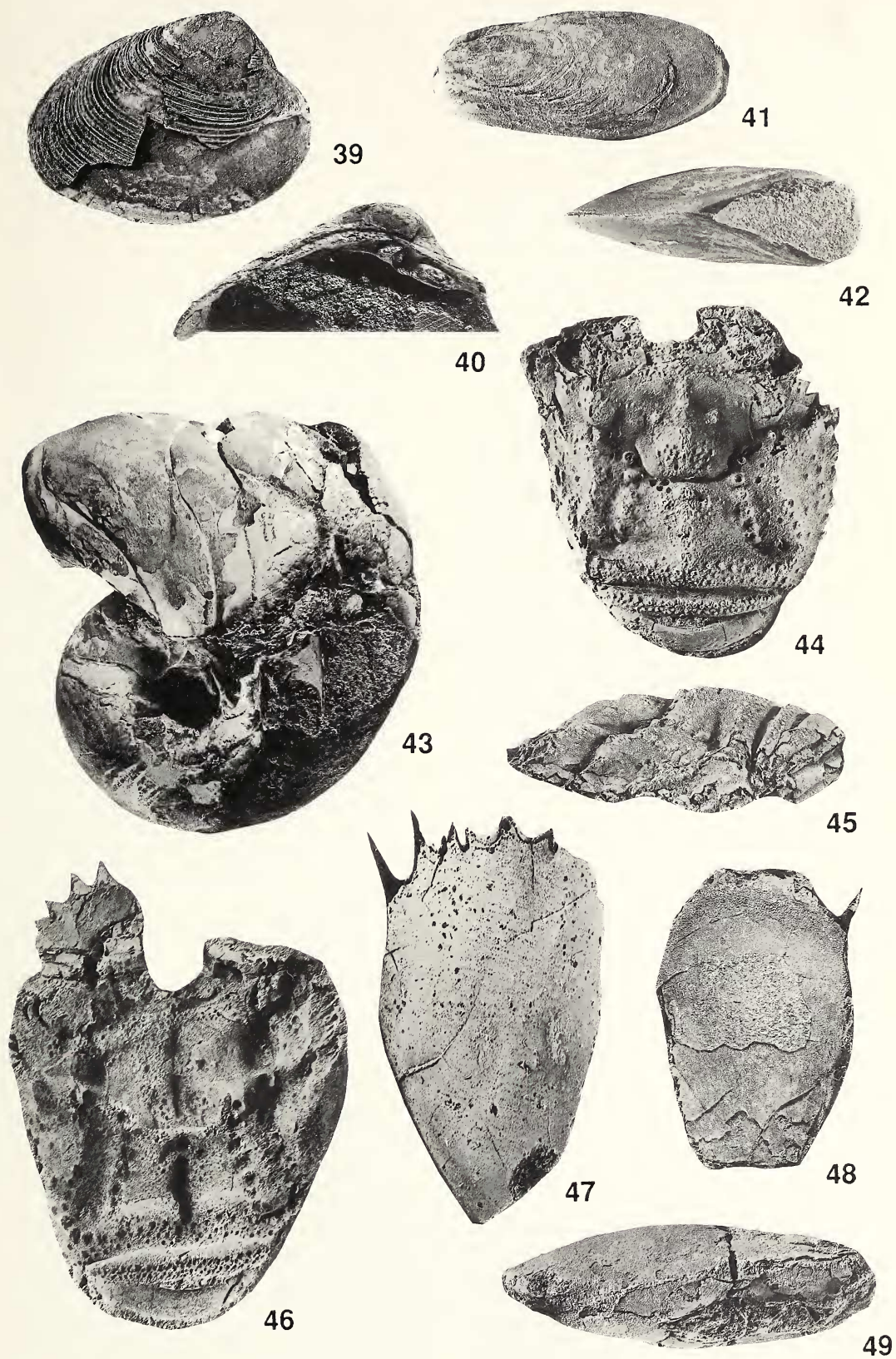
GEOGRAPHIC DISTRIBUTION. San Diego and Simi Valley, California.

LOCAL OCCURRENCE. LACMIP loc. 15450, CSUN loc. 548.

REMARKS. Two specimens are known from the Llajas Formation. Both are internal molds of closed-valved specimens. The type of substrate the specimens lived in is unknown. The Llajas Formation specimens differ from the type specimens of *Gastrochaena dubitata* Hanna (1927:298, pl. 45, figs. 1, 2) by being narrower, but this difference might be the result of the type of substrate the specimens lived in. Gastrochaenids have an endolithic mode of life and bore or burrow into soft rock,

→

Figures 39-49 Bivalves, nautiloid, lobster, and crab from the Llajas Formation. All specimens coated with ammonium chloride. 39-42. Bivalves. 39, 40. *Pitar uvasana coquillensis* Turner, 1938, CSUN loc. 374. 39. Right valve, $\times 1.2$, LACMIP hypotype 12756. 40. Left-valve hinge, $\times 1.8$, LACMIP 12757. 41, 42. *Gastrochaena ?dubitata* Hanna, 1927, $\times 2.9$, LACMIP hypotype 12758, CSUN loc. 548. 41. Left valve. 42. Ventral view. 43. Nautiloid. *Kummelonautilus* sp., lateral view, $\times 0.8$, LACMIP hypotype 12759, CSUN loc. 374. 44-46. Lobster. *Parribacus caesius* n. sp., $\times 2.3$, LACMIP holotype 12760, CSUN loc. 548. 44. Dorsal view. 45. Lateral view. 46. External mold of specimen shown in Figures 43, 44. 47-49. Crab. *Raninoides slaki* n. sp., CSUN loc. 548. 47. Dorsal view, $\times 2.3$, LACMIP holotype 12761. 48. Dorsal view, $\times 2$, LACMIP paratype 12762. 49. Left-lateral view, $\times 3$, LACMIP paratype 12763



other shells, coral heads, or coral debris (Keen, 1971; Carter, 1978), and how much variation in length/height a species has can depend upon the type of substrate, primarily in species that bore into siliceous material (Carter, personal communication). More specimens of *G. dubitata* are needed in order to determine how much variation in length/height there is in this species and what type of substrate this species preferred.

Gastrochaena dubitata is the only reported species of this genus in the Paleogene rock record of the Pacific coast of North America.

Class Cephalopoda Cuvier, 1798

Order Nautilida Agassiz, 1847

Family Nautilidae Blainville, 1825

Genus *Kummelonautilus* Matsumoto in
Matsumoto et al., 1984

TYPE SPECIES. *Kummeloceras yamashitai* Matsumoto, 1983, by original designation; Late Cretaceous (Turonian Stage), Japan.

Kummelonautilus sp.

Figure 43

LOCAL OCCURRENCE. CSUN locs. 374, 444, 548.

REMARKS. Eight specimens are known from the Llajas Formation. Except for three fragmentary specimens from CSUN locality 444, they are complete and range in diameter from 3 to 11.5 cm. All have been crushed to varying degrees, and none shows the siphuncle. Any attempt to expose a siphuncle would result in the destruction of the specimen. The specimens are internal molds, with some small patches of shell intact. On the best preserved specimen (Fig. 43), the umbilicus is well defined and the septal suture is moderately well exposed, although the umbilical margin is somewhat obscured and the dorsal lobe is unavailable for study. The septal suture shows a moderately pronounced ventral saddle, a broad but distinct lateral lobe, and a small lateral saddle at the umbilical margin. Unfortunately, on the most mature part of this specimen, the central portion of the ventral saddle and the region of the lateral lobe in the vicinity of the umbilicus have been obscured by the effects of crushing. This crushing probably accounts for the rather wide separation of the last chamber on the most mature part of the shell.

Matsumoto (1983) established a new genus, *Kummeloceras* (type species *Kummeloceras yamashitai* Matsumoto, 1983) for two nautilid species from Upper Cretaceous (Turonian to Coniacian) rocks of Hokkaido, Japan. He also applied the name to several previously named Late Jurassic, Cretaceous, and early Tertiary (i.e., referred to by him as Eocene in age) nautilids, all of which had been variously assigned to other genera. In a postscript by Matsumoto in Matsumoto et al. (1984:

345), he noted that the generic name *Kummeloceras* was preoccupied by a Permian genus; thus, he proposed the name *Kummelonautilus*. Teichert and Matsumoto (1987) and placed *Kummelonautilus* in family Nautilidae.

The Llajas specimens are assigned to *Kummelonautilus*, based on their having a septal suture pattern that is very similar to that of *K. yamashitai* (Matsumoto, 1983:18–19, pl. 4, fig. 1; pl. 5, fig. 1; pl. 6, fig. 1; pl. 7, fig. 1; text figs. 3E, 4–6), the type species of *Kummelonautilus*. The specific identification of the Llajas material, however, awaits better preserved specimens.

Matsumoto (1983) assigned two early Tertiary species to genus *Kummeloceras* [now known as *Kummelonautilus*]. One is *K. cookanus* (Whitfield, 1892:285–286, pl. 48, fig. 1; pl. 49, figs. 4, 5) from the Shark River Marl, northeastern New Jersey. Ward (1984;text fig. 1) correlated this formation to the middle Eocene. The septal suture pattern of *K. cookanus* is similar to that of the Llajas Formation species, but it is difficult to make detailed comparisons because the Llajas material has been so crushed. It does appear, however, that the lateral lobe of the best preserved Llajas specimen is less pronounced than the lateral lobe of *K. cookanus*.

Kummelonautilus cookanus was originally named *Nautilus cookana* Whitfield, 1892. Miller (1947) placed this taxon in genus *Eutrephoceras* Hyatt, 1894. Matsumoto (1983) named *Kummeloceras* [now known as *Kummelonautilus*] and assigned Whitfield's species to it. Squires (1988d:76–79, figs. 2.1, 3.1–3.4), in an attempt to identify a nautiloid specimen from the upper Eocene Hoko River Formation in Washington, reported that it had remarkable affinity to *Nautilus cookanum*. In his opinion, the sinuosity of the septal suture of this Washington specimen was more like that of a *Nautilus* than an *Eutrephoceras*, where it had been placed since the mid-1900s (e.g., Miller, 1947). Squires was unaware of Matsumoto's (1983) creation of a new genus that could accommodate both the Washington specimen and Whitfield's species. Ward and Saunders (1997), in their cladistic analysis of certain nautilid taxa, also placed Whitfield's species in genus *Nautilus*, and they reported that *N. cookanum* also occurs in the upper middle Eocene Cowlitz Formation in Washington. Harvey et al. (1999), in their own cladistic analysis of the same taxa studied by Ward and Saunders (1997), concluded that Whitfield's species belongs to genus *Kummelonautilus*. Ward (1999), however, in an emended cladistic analysis, retained the assignment as *Nautilus cookanum*. All of this taxonomic reshuffling, even when rigorous cladistic techniques are employed, indicates how confusingly similar certain nautilid genera can be in their morphology. Certainly, there is a need for the establishment of better distinctions among those nautilid taxa that have such similar septal suture patterns. Future work might show that *Kummelonautilus* and *Nautilus* are the same.

The second early Tertiary species that Matsu-moto (1983) assigned to *Kummelonautilus* is *K. bryani* (Gabb, 1877:277; Whitfield, 1892:244–245, pl. 38, figs. 5, 6) from the Vincentown sand in New Jersey. Ward (1984:text fig. 1) correlated this formation to the late Paleocene. This species does not have a ventral saddle and, in that respect, is unlike *Kummelonautilus* sp. from the Lajas Formation.

The Lajas specimens of *Kummelonautilus* represent the earliest record of this genus on the Pacific coast of North America and its first record in California.

Phylum Arthropoda Siebold and Stannius,
1848

Class Malacostraca Latreille, 1806

Order Decapoda Latreille, 1803

Family Scyllaridae Latreille, 1825

Genus *Parribacus* Dana, 1852

TYPE SPECIES. *Scyllarus antarcticus* Lund, 1793, by subsequent designation (ICZN Opinion 519 in 1958); Western Atlantic region (Florida, West Indies, northeast Brazil) and Indo-West Pacific region (east and southeast Africa to Polynesia and Hawaii).

Parribacus caesius new species

Figures 44–46

DIAGNOSIS. Anteriormost antennal segment strongly serrate, carapace wider than long, cervical incision small, five tubercles on median carina in cardiac region, a lowly tuberculate urogastric region, and no transverse median groove on the first and second segments.

DESCRIPTION. Anteriormost antennal segment on right side of carapace with four very strong teeth. Carapace wider than long, granulated, dorsoventrally more or less flattened. Frontal area with a row of small tubercles. Orbits probably near anterolateral area. Gastric region inflated and crossed by the median carina; anterior gastric region with three tubercles, one on the median carina and one on each side of the carina; posterior gastric region well delineated and with a cluster of small tubercles centered around the raised and tuberculate? median carina. Hepatic regions swollen near their centers and with scattered tubercles anteriorly. Cervical groove deep, mostly smooth, passing from a small but distinct incision along anterolateral area to about the middle of the carapace; cervical groove narrowest at the median carina and perpendicular to the median carina. Branchial regions with scattered tubercles near margin of carapace and with two ridges that pass into each other; one ridge borders the cervical groove and the other, which is tuberculate, is apart from, but parallel to, the branchiocardiac groove. The latter ridge also passes into a tuberculate ridge along the posterior margin of the carapace. Branchiocardiac groove with four to

five large tubercles; an additional tubercle is situated in the adjacent and deeper cervical groove. Gastric region swollen and with five tubercles (becoming stronger anteriorly) on median carina; between the two anteriormost tubercles are two smaller ones on each side of the median carina. Lateral border of carapace with short, stout spines. Abdominal segments (first to third) with two to three rows of small tubercles on the raised areas. First abdominal segment 2 mm wide; second and third segments about 4 mm wide.

COMPARISON. The serrated anteriormost antennal segment of the new species is like that found on species of *Parribacus* and on species of *Scyllarus* Fabricius, 1775. The new species, however, is more like *Parribacus* because there is a cervical incision on the lateral margin of the carapace, and the carapace is lowly arched rather than highly arched (J. W. Martin, personal communication). The new species is provisionally assigned to *Parribacus* because it is likely that the new species belongs to a new genus of scyllarid lobsters, with close affinities to *Parribacus*, *Scyllarus*, and *Scyllarides* (Gill, 1898).

The morphology of the dorsal surface of the carapace of the new species is similar to that found on some species of *Scyllarides*. In particular, the new species is similar to *S. tuberculatus* (König, 1825) from the lower Eocene London Clay of England. Woods (1925:39–41, pl. 10, figs. 7–10), Glaessner (1969:fig. 281,3), and Quayle (1987:606, 608–609, pl. 67, fig. 106) illustrated this English species. The morphologic similarities are the general shape of the carapace, the pattern of the cervical groove (perpendicular to the median carina and directed anterolaterally beyond the median carina), the tuberculate median carina (extending across both the gastric and cardiac regions), and the raised and tuberculate branchial areas. The new species differs from *S. tuberculatus* by having a wider carapace and stronger and more localized tubercles, especially on the median carina, on the branchial ridges and on the branchiocardiac groove. In addition, there is no transverse median groove on the second abdominal segment of the new species. The new species does not belong in genus *Scyllarides* because the margin of the anteriormost antennal segment of the new species is strongly serrate, whereas, as reported by Holthuis (1991), on genus *Scyllarides* the margin is always smooth. Unfortunately, the margin of the anteriormost antennal segment of *S. tuberculatus* is not known. The generic assignment of *S. tuberculatus*, therefore, is uncertain.

HOLOTYPE DIMENSIONS. Total length 25 mm (incomplete); carapace length 17 mm (incomplete), carapace width 22 mm.

PRIMARY TYPE MATERIAL. LACMIP holotype 12760, CSUN locality 548.

MOLLUSCAN STAGE RANGE. “Domengine.”

GEOGRAPHIC DISTRIBUTION. CSUN locality 548.

LOCAL OCCURRENCE. CSUN loc. 548.

REMARKS. A single specimen is known from

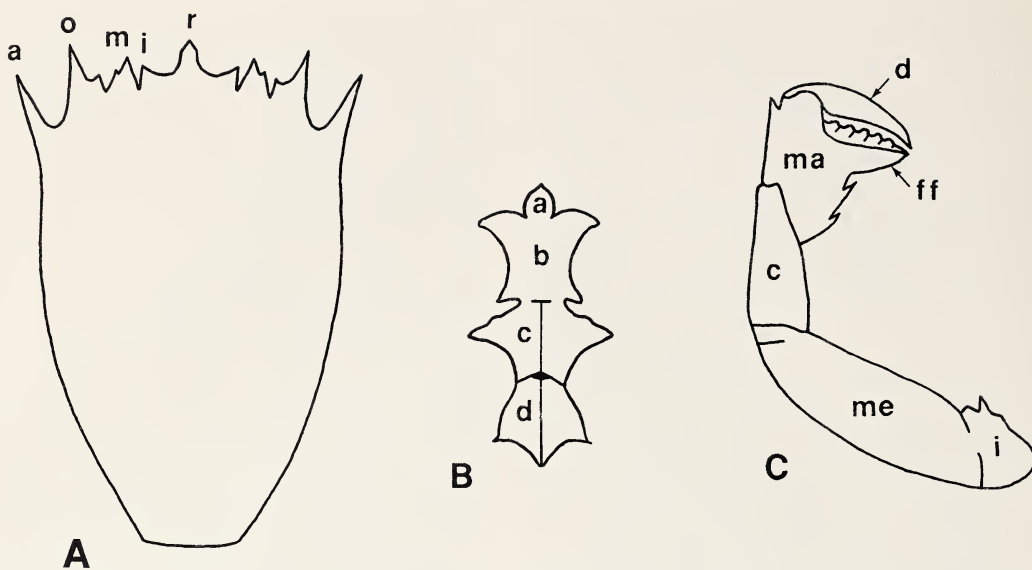


Figure 50 Outline drawings of *Raninoides slaki* n. sp., $\times 2.3$. A. Dorsal view of carapace: a, anterolateral spine; o, outer orbital tooth; m, medial orbital tooth; i, inner orbital tooth; r, rostrum. B. Ventral view of sternum: a, sternites 1-3; b, sternite 4; c, sternite 5; d, sternite 6. C. Dorsal view of first pereiopod: i, ischium; me, merus; c, carpus; ma, manus; ff, fixed finger; d, dactylus

the Llajas Formation. It consists of the posterior regions of the antennal area, the carapace, and the first three abdominal segments. The third abdominal segment is poorly preserved. The frontal area of the carapace is badly crushed. The ventral surface of the specimen is not exposed. On the anterior region of the external mold of this specimen, the best preserved antennal segment shows short but stout teeth, which is a key morphologic characteristic of this group of lobsters.

Parribacus has been reported previously only from ?Upper Cretaceous (Cenomanian Stage) strata in Lebanon and from modern seas (Glaessner, 1969).

ETYMOLOGY. The species is derived from *caesi*us, Latin, meaning bluish-gray, in reference to the color of the weathered specimen.

Family Raninidae Haan, 1841

Genus *Raninoides* Milne-Edwards, 1837

TYPE SPECIES. *Raninoides laevis* (Latreille, 1825), by original designation; Recent, Colombia.

Raninoides slaki new species

Figures 47-55

DIAGNOSIS. A *Raninoides* with short medial orbital tooth, carapace widest usually near medial part and width about 58 percent of total length, and alate processes on sternite 5 projecting farther than those on sternite 4.

DESCRIPTION. Medium sized, 9 to 31.2 mm in length, 5 to 19.6 mm in width. Carapace usually ovate (egg-shaped), some specimens more straight-sided, largest specimen (Fig. 53) triangular shaped; greatest width usually located near medial part of margin of carapace and about 58 percent of total length; carapace slightly convex longitudinally, more arched transversely; carapace finely punctate, granulate along margins, especially on ventral side; row of granules along edge of dorsal side of carapace. Subhepatic margins moderately narrow, well delineated from unswollen to slightly swollen pterygostomial regions that taper anteriorly to pointed ends. Width of fronto-orbital margin about 72 percent of extreme width of carapace. Outer orbital tooth bifurcate with exterior spine produced almost

Figures 51-57 Crabs from the Llajas Formation. All specimens coated with ammonium chloride. 51-55. *Raninoides slaki* n. sp., CSUN loc. 548. 51. Dorsal view, $\times 2$, LACMIP paratype 12764. 52, 53. LACMIP paratype 12765. 52. Dorsal view, $\times 1.6$. 53. Ventral view, $\times 2$. 54. Ventral view, $\times 3$, LACMIP paratype 12766. 55. Claw, $\times 7.6$, LACMIP paratype 12767. 56. *Portunites insculpta* Rathbun, 1926, dorsal view, $\times 2.4$, LACMIP hypotype 12768, CSUN loc. 548. 57. *Palaeopinnixa* aff. *Palaeopinnixa rathbunae* Schweitzer et al., 2000, dorsal view, $\times 6.5$, LACMIP hypotype 12769, CSUN loc. 548



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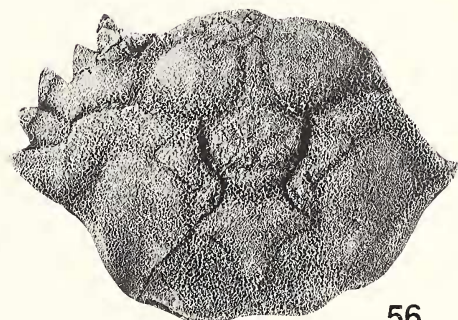
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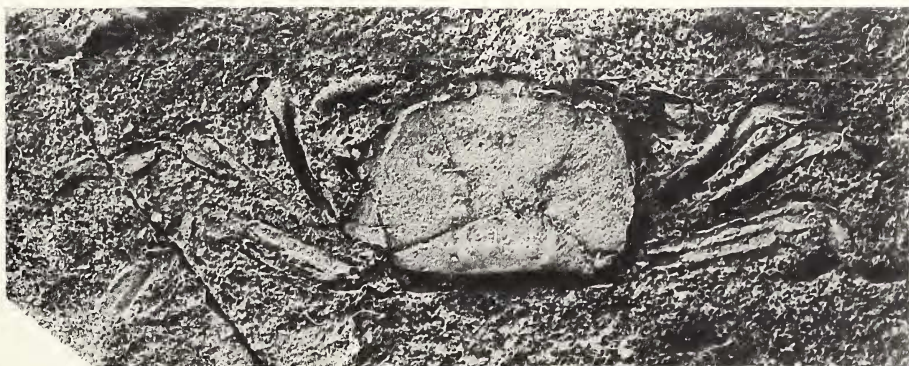
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to tip of rostrum, separated from inner spine by a broad, shallow concave margin; inner spine short, blunt. Medial orbital tooth bifurcate, with inner spine longest, produced approximately equal to inner orbital tooth. Inner orbital tooth separated from base of rostrum by U-shaped margin, spine directed more outward than forward. Rostrum with base approximately equal to length, not downturned, not extending beyond orbital teeth. Anterolateral spines directed forward and somewhat outward, forming a U-shaped angle with the carapace. Thoracic appendages generally elongate, narrow, flattened laterally. Third maxillipeds with ischium about four times as long as wide, extending to near anterior of pterygostomial region; anterior end of ischium bifurcate with inner part longest. Merus about 75 percent as long as ischium and wider, tapering anteriorly to a bluntly pointed end on its inner side. Exopod of third maxilliped long, slender, curved, and extending to near anterior of pterygostomial region. Sternum narrow, elongate. Sternites 1–3 (fused) narrow anteriorly to form a pointed termination, broaden at midlength to form rounded margins, and separated from sternite 4 by slight lateral emargination. Anterior of sternite 4 expanding laterally to sharp-tipped alate processes; base of sternite narrower than anterior and marked by two sharp-tipped alate processes. Length of sternite 4 proportionally longer in the larger specimens than in more juvenile specimens. Anterior part of sternite 5 constricted; central part of sternite 5 expanding to pointed alate processes, which extend farther than any of the alate processes of sternite 4, then converging toward posterior. Juncture of sternites 5 and 6 marked by forward-arching distinct groove and by a deep pit, axially located. Anterior part of sternite 6 slightly concave; posterolateral parts expanding to alate processes. Axial cleft on sternites 5 and 6. Junction of sternites 6 and 7 marked by a strongly sinuous border, whose axial part points posteriorly. Axial cleft on sternites 5 and 6. At least two abdominal somites (1, 2) visible dorsally and not as wide as posterior margin of carapace. First pereopods opposite sternite 4, with a small spine on anterior side of ischium; merus about as long as the combined length of the carpus and manus. Inner side of manus with two small spines, outer side of manus near dactylus with one small spine. Fixed finger with about five small but stout teeth. Dactylus smooth. Other appendages unknown, except for small fragments.

COMPARISON. According to Schweitzer et al. (2000), generic assignment of taxa to *Raninoides* is difficult at best, because there are no unequivocal characters with which to distinguish it from genus *Laeviranina* Lörentz and Beurlen, 1929. These workers believed it premature to assert that these two genera are synonymous until more work is done (pending better preservation) comparing their sternal and cheliped features. Tucker (1998) noted that the ischium of the first pereopod of *Raninoides* bears a spine; however, this element of the pe-

reopods of *Laeviranina* is unknown. The new species bears this spine. Other equivocal? features that tend to indicate that the new species belongs to *Raninoides* are the elongate and convex carapace with a smooth surface, and greatest width behind the middle part; a fronto-orbital border less than greatest width of carapace, no postfrontal ridge or escarpment; and sternite 5 broad in the middle and narrow posteriorly.

The new species was compared to all known described species of *Raninoides* from the fossil record of the Pacific coast of North America. These species, which are mostly only found in Washington, are described and illustrated in Rathbun (1926). Of these species, the new species is most similar to *R. washburnei* Rathbun, 1926, and *R. dickersoni* Rathbun, 1926. Although the details of the orbital teeth and rostrum of *R. washburnei* are not well known, the new species differs from *R. washburnei* Rathbun (1926:95, pl. 22, fig. 6; Orr and Kooser, 1971:147, figs. 3b, 3c, 4d–f) by having a narrower carapace that is widest near the middle rather than just posterior of the frontal area, much less outward-projecting anterolateral spines, more alate processes on sternites 4 and 5, more posteriorly located lateral extensions on sternite 6, much finer punctations on the carapace, and no submedian grooves on the carapace.

Raninoides washburnei is known from the “upper Umpqua Formation” about 5 km east of Agness, Oregon (Orr and Kooser, 1971), at “Basket Point” on the Umpqua River near Tyee in Douglas County, Oregon [= UCMF localities A-696 to A-700], and from Oligocene rocks near Eugene, Oregon (Rathbun, 1926). The “upper Umpqua Formation” east of Agness is now mapped as the middle Eocene Flournoy Formation (Baldwin, 1975). Heller and Dickinson (1985) assigned the Flournoy Formation to the middle Eocene P11 Zone of the standard planktonic foraminiferal zonation. Rathbun (1926) did not assign the rocks at “Basket Point” to a formation, but Hoover (1963:D-27) assigned them to the middle Eocene Tyee Formation. According to R. Berglund (personal communication), the rocks at “Basket Point” are part of the Elkton Formation, which was considered by some early authors to be a member of the Tyee Formation. Heller and Dickinson (1985:fig. 3) assigned the Elkton Formation to the middle Eocene P12 Zone of the standard planktonic foraminiferal zonation.

Raninoides washburnei? Rathbun, 1926, has also been reported from the Cozy Dell Shale in the upper Sespe Creek area, Ventura County, California. As reviewed by Squires (1984), the geologic age of the Cozy Dell Shale is middle Eocene, which is equivalent to the middle part of the “Tejon Stage.” Squires (1994:pl. 1, fig. 11) illustrated one of these Cozy Dell Shale specimens, and the new species differs from it by having the anterolateral spine closer to the outer orbital spine and by having a less projected rostrum.

Although the dorsal part of the carapace and the details of the orbital teeth and rostrum of *Raninoides dickersoni* are not well known, the new species differs from *Raninoides tejonensis* Rathbun (1926: 94–95, pl. 20, fig. 5; Dickerson, 1916: pl. 42, figs. 12 [as ?*Cancer* sp. b]) by having sternite 4 much narrower posteriorly, sternite 5 longer and without small forward-directed “points” on the lateral alate processes, an axially unnotched juncture between sternites 5 and 6, third maxillipeds narrower and not rounded at anterior end or with a deep inner groove, exopod of third maxilliped narrower, and much finer punctations on the lower surface of the carapace. *Raninoides tejonensis* is known from Salt Creek near Coalinga, California, in rocks now assigned (Squires, 1988c) to the lower Eocene (“Caypay Stage”) Cerros Shale Member of the Lodo Formation.

Cushman and McMasters (1936) reported several specimens of *Raninoides vaderensis* Rathbun, 1926, in a drill core in the Llajas Formation taken from Tapo oil well number 42 [= LACMIP locality 17115]. It is very likely that these specimens were conspecific with the new species. Cushman and McMasters (1936) provided no illustrations but did mention that the specimens were deposited in the USNM. Unfortunately, no museum catalog numbers were assigned to the specimens. A search, initiated by the author, revealed that these specimens could not be found in the USNM collections (W. Blow, personal communication).

Tucker (1998:353–355, figs. 17.1, 17-2, 17-4, 17-5, 18) showed that *Raninoides vaderensis* Rathbun (1926:93, pl. 22, fig. 5) belongs to *Laeviranina*. Schweitzer et al. (2000:34–36, fig. 3A), furthermore, showed that *L. vaderensis* (Rathbun) is synonymous with *Laeviranina lewisiana* (Rathbun, 1926:94, pl. 22, fig. 4; Tucker, 1998:350–353, figs. 15, 16). *Laeviranina vaderensis* is known from middle Eocene rocks in Oregon, Washington, and Alaska, as well as upper Eocene rocks in Washington (Tucker, 1998). The new species differs from *L. vaderensis* by having a wider carapace, rostrum much less projected, outer orbital tooth wider posteriorly but more projected anteriorly, outer orbital tooth directed more outward, medial tooth much shorter, and the alate processes on sternite 4 more produced.

HOLOTYPE DIMENSIONS. Length 30 mm (incomplete), width 17 mm (incomplete).

PRIMARY TYPE MATERIAL. LACMIP holotype 12761 and LACMIP paratypes 12762–12767; all types from CSUN locality 548, Llajas Formation, Simi Valley, California.

MOLLUSCAN STAGE RANGE. “Domengine.”
GEOGRAPHIC DISTRIBUTION. Simi Valley, California.

LOCAL OCCURRENCE. LACMIP loc. 17115, CSUN loc. 548.

REMARKS. Ninety specimens were collected from the Llajas Formation. Nearly all of these were found in one small area in association with pieces

of driftwood. Preservation of the crab specimens is moderately good. Most are internal molds with only portions of the thin carapace present. Some specimens show the ventral surface and the sternum. A few specimens have the arms of the first pereiopod intact. Only three complete chelipeds with attached arms were found. One is attached to the carapace and the other two are isolated. On a few specimens, the abdomen is partially present. The front-orbital margin with its protruding teeth and spines are only preserved on very few specimens, and the features of the orbits are not preserved. The outline drawings of the new species shown in Figures 50A–C are based on a study of all the collected specimens.

The new species is the first fossil *Raninoides* from the fossil record of the Pacific coast of North America to have one of its first pereiopods preserved intact.

ETYMOLOGY. The new species is named for Greg Slak, who found all the specimens, generously shared them, skillfully participated in their identification, and provided some detailed drawings of them. Without his careful and meticulous collecting, as well as his kind cooperation, this new species would not have been part of this report.

Family Portunidae Rafinesque, 1815

Genus *Portunites* Bell, 1858

TYPE SPECIES. *Portunites incerta* Bell, 1858, by original designation; Eocene, England.

Portunites insculpta Rathbun, 1926

Figure 56

Portunites insculpta Rathbun, 1926:71–72, pl. 17, figs. 1, 2.

PRIMARY TYPE MATERIAL. USNM holotype 353347, upper middle Eocene Elkton Formation, “Basket Point” on the Umpqua River near Tyee, Douglas County, Oregon [= UCMP localities A-696 to A-700].

MOLLUSCAN STAGE RANGE. “Domengine” to middle part of “Tejon.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, and near Elkton, Oregon.

LOCAL OCCURRENCE. LACMIP loc. 17115, CSUN loc. 548.

REMARKS. Two specimens are known from the Llajas Formation. Both are internal molds. One partially shows the dorsal side of the carapace, and the other one shows the ventral side of the carapace, as well as a portion of the dorsal side.

Although *Portunites insculpta* was reported by Cushman and McMasters (1936) as being present in drill-core samples in Tapo oil well number 42 [= LACMIP loc. 17115] in the Llajas Formation, they did not illustrate any specimens. The specimen illustrated in Figure 56 of this report is the first Llajas Formation specimen of *P. insculpta* to be illustrated.

The presence of *Portunites insculpta* in the Llajas Formation is the first record of this species outside of Oregon. As mentioned in the Comparison section of *R. slaki*, "Basket Point" on the Umpqua River in southwestern Oregon, which is where the type locality of *P. insculpta* is located, corresponds to the upper middle Eocene Elkton Formation.

Family Hexapodidae Miers, 1886

Genus *Palaeopinnixa* Via, 1966

TYPE SPECIES. *Palaeopinnixa rathbunae* Schweitzer et al., 2000, by original designation; middle Eocene, Washington.

Palaeopinnixa aff. *Palaeopinnixa rathbunae* Schweitzer et al., 2000

Figure 57

LOCAL OCCURRENCE. CSUN loc. 548.

REMARKS. A single specimen is known from the Llajas Formation. It is an internal mold, solidly embedded in rock. Only the dorsal side of the carapace is visible, but all the walking legs and chelipeds are visible. The carapace is subrectangular, with a length of 4 mm and a width of 5.5 mm. The length to width ratio is 0.73, where length is measured from anterior (rostrum) to posterior. The anterolaterals are subrounded. The front (rostrum) is projected, deflexed, about one-fourth the width of the carapace, minutely notched, and with a medial groove or line. The orbits are moderately long (about as long as the projected front). The posterior margin is straight. The cervical grooves along the sides of the gastric and mesogastric regions form an H-shaped feature that flares anteriorly. A row of low tubercles (approximately six) parallels the outer side of this H-shaped feature. The propodus (palm) is broad and the rest of the chelipeds are obscured. There are only three pairs of walking legs. They are all about the same width, although the third pair appears to be slightly larger. The second and third pair have longitudinal furrows and are longer than the first pairs of legs. The possibility that the specimen originally had four pairs of walking legs, and lost the most posterior pair after death, is ruled out because the third pair of legs is attached to the extreme corners of the carapace. There is no space, whatsoever, where a fourth pair of legs could have been attached. In addition, there is no evidence of any coxa present, where the fourth pair of legs would have been attached.

The absence of a fourth pair of walking legs allows for the assignment of the Llajas specimen to family Hexapodidae, which is referred to by some authors as "hexapod crabs." The Llajas specimen was compared with all known hexapod species, fossil and Recent, and the specimen belongs to *Palaeopinnixa* Via, 1966, a taxon reviewed by Schweitzer et al. (2000).

The Llajas specimen has affinity to *P. rathbu-*

nae Schweitzer et al. (2000:57–63, figs. 15–17) from the middle Eocene Aldwell? Formation and the upper Eocene Hoko River Formation, both of which crop out on the Olympic Peninsula, Washington. The Llajas specimen differs from *P. rathbunae* by having a narrower carapace, a rather featureless mesogastric area that is not triangular and not narrow anteriorly, an H-shaped cardiac region rather than a subtriangular one, cardiac and mesogastric regions with a row of low tubercles on each side, an absence of three swellings arranged in a triangular pattern on the cardiac region, longitudinal furrows on the second and third pairs of walking legs, and an absence of two small protogastric swellings located at base of rostrum.

Schweitzer and Feldmann (2001) reported that *P. rathbunae* is most closely related to *Palaeopinnixa rotundus* Schweitzer and Feldmann (2001: 336–337, figs. 3–4) from the upper middle to upper Eocene Coaledo Formation in Oregon. The Llajas specimen differs from *P. rotundus* by having a more rectangular carapace whose sides are not steeply rounded, an H-shaped cardiac region rather than a triangular one, more indented cervical grooves in the posterior mesogastric region, cardiac and mesogastric regions with a row of low tubercles on each side, and an absence of two swellings anteriorly and one posteriorly on the cardiac region.

The Llajas specimen is similar to *Palaeopinnixa prima* (Rathbun, 1919:176–177, pl. 66, figs. 15–18) from Oligocene rocks in the Panama Canal Zone. The Llajas specimen differs from *P. prima* by having the third pair of walking legs similar in strength to the second pair, a medial groove on the projected front, longer orbits, and cardiac and mesogastric regions with a row of low tubercles on each side.

The Llajas specimen is also similar to *Palaeopinnixa eocenica* (Woods, 1922:117–118, pl. 17, fig. 11) from the Negritos Formation in Peru. This formation, now called the Negritos-Salina Formation or Basal Salina Formation, is of early Eocene age, according to Marsaglia and Carozzi (1991). The walking legs are missing on *P. eocenica*. The Llajas specimen differs from *P. eocenica* by having a medial groove on the projected front, less robust palms, and no lateral furrows on each side of the middle region of the carapace.

The Llajas specimen might represent a new species, but better preservation of the entire carapace (both dorsal and ventral surfaces) and of the arms of the chelipeds is needed before a specific name should be given to the specimen.

Palaeopinnixa is known from strata of earliest Paleocene age in Argentina (Feldmann et al., 1995); early Eocene age in Peru (Woods, 1922); middle Eocene age in southern California (herein); middle to late Eocene age in Washington (Schweitzer et al., 2000; Schweitzer and Feldmann, 2001); Oligocene age in the Panama Canal Zone (Rathbun, 1919); and Miocene age in Trinidad (Collins

and Morris, 1978) and Spain (Via, 1966). In the CSUN fossil collection, there is a poorly preserved hexapod crab specimen from CSUN locality 1603 in upper Paleocene rocks in the upper Santa Susana Formation in Temescal Canyon of the Santa Monica Mountains, Los Angeles County, California. The Santa Susana specimen is missing all of its appendages, but the shape and size of the carapace strongly resemble *Paleopinnixa*. An attempt to find more specimens was unsuccessful, but eventually more specimens might be found, and if so, they might represent the earliest known *Paleopinnixa* from the Pacific coast of North America.

Phylum Echinodermata Klein, 1734

Class Echinoidea Leske, 1778

Order Temnopleuroida Mortensen, 1942

Family Temnopleuridae A. Agassiz, 1872

Genus *Brochopleurus* Fournau, 1920

TYPE SPECIES. *Temnechinus stellulatus* Duncan and Sladen, 1886, by original designation; middle Miocene, western Pakistan.

?*Brochopleurus* sp.

Figures 58–61

LOCAL OCCURRENCE. CSUN loc. 548.

REMARKS. Two partial specimens are known from the Llajas Formation. Both are internal molds of fragmentary and somewhat crushed specimens. The best preserved (Figs. 58–61) is in matrix and is a slightly crushed fragment about 25 mm long and 15 mm wide. The only original test material present is associated with some of the bases of the primary tubercles.

The Llajas specimens are small, flattened below, and slightly rounded above. There is only one primary tubercle to each plate. The tubercles are imperforate, noncrenulate, and in single series, both adapically and adorally, and they have 10 to 12 radiating costae around their bases. The ambulacral tubercles are slightly smaller than the interambulacral tubercles. The pores of the ambulacral plates are in straight vertical series and are round.

Although poorly preserved, the observable features on the tests of the Llajas specimens best fit (Y. Albi, personal communication) the morphologic characteristics of genus *Brochopleurus*, but better material is needed to confirm this identification. The Llajas specimens are also similar to genus *Scolecchinus* Lambert and Thiéry, 1925, which also has distinct radiating sculpture around the imperforate primary tubercles. The only morphologic distinction between *Brochopleurus* and *Scolecchinus* is that the former has round pores and the latter has angular pores. *Brochopleurus* is more widespread and has a geologic range of Eocene to Miocene (Fell and Pawson, 1966). Although most of its occurrences are in the Old World, it has been found in Alabama (Cooke, 1959). *Scolecchinus* is known only from

North Africa and has a geologic range of Oligocene to Miocene (Fell and Pawson, 1966).

In terms of the radiating costae around the bases of the primary tubercles, the Llajas specimens are superficially like *Arachniopleurus* Duncan and Sladen, 1882, and *Radiocyphus* Cotteau, 1890, both of which belong to the Glyphocyphidae Duncan, 1889. Both of these genera, however, have perforate tubercles and, in that feature, are unlike the Llajas specimens.

These Llajas specimens represent the first occurrence of a temnopleurid echinoid in the Paleogene rock record of the Pacific coast of North America.

Order Cassiduloida Claus, 1880

Family ?Pliolampadidae Kier, 1962

Genus *Calilampas* Squires and Demetron, 1995

TYPE SPECIES. *Calilampas californiensis* Squires and Demetron, 1995, by original designation; early Eocene (“Capay Stage”), Baja Sur California, Mexico.

Calilampas californiensis Squires and Demetron, 1995

Figures 62, 63

Calilampas californiensis Squires and Demetron, 1995:514–515, figs. 5.1–5.7, text figs. 6, 7.

PRIMARY TYPE MATERIAL. IGM holotype 6387 from CSUN locality 1546; IGM paratype 6388 from CSUN locality 1546; IGM paratype 6389 from CSUN locality 1544a; IGM paratype 6390 from CSUN locality 1544; IGM paratype from CSUN locality 1576; LACMIP paratype 11532 from LACMIP locality 26622; all IGM type material from “Capay Stage” part of Bateque Formation, Baja California Sur, Mexico; LACMIP type material from “Capay Stage” part of Llajas Formation, Simi Valley, California.

MOLLUSCAN STAGE RANGE. “Capay Stage.”

GEOGRAPHIC DISTRIBUTION. Baja California Sur, Mexico and Simi Valley, California.

LOCAL OCCURRENCE. LACMIP loc. 26622.

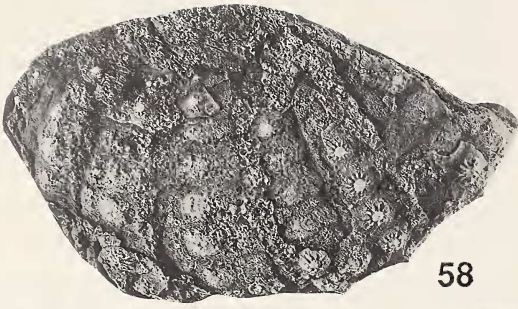
REMARKS. A single specimen is known for the Llajas Formation. It is complete and moderately well preserved, although some of the shell is missing. Although the Llajas Formation specimen (LACMIP paratype 11532) of this species was reported by Squires and Demetron (1995) as having been found in the Llajas Formation, the specimen previously was not illustrated; therefore, an illustration is included in this report.

Order Spatangoida Claus, 1876

Family Brissidae Gray, 1855

Genus *Eupatagus* L. Agassiz in Agassiz and Desor, 1847

TYPE SPECIES. *Eupatagus valenciennesi* L. Agassiz in Agassiz and Desor, 1847, by subsequent designation (Pomel, 1883); Recent, Australia.



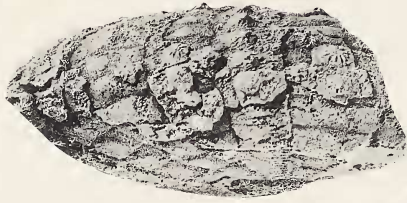
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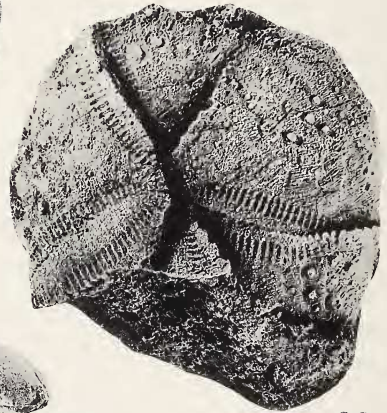
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Eupatagus stevensi Grant and Hertlein, 1938

Figures 64–67

Eupatagus stevensi Grant and Hertlein, 1938:134–135, text fig. 12.

PRIMARY TYPE MATERIAL. LACMIP holotype 9134 [= UCLA holotype 7715], exact locality unknown, Chivo Canyon area [= Oil Canyon], Llajas Formation, Simi Valley, California; CAS paratypes 28490.01–28490.03, CAS locality 28490, Eocene formation not known, Reyes Creek in upper Cuyama River, Ventura County, California.

MOLLUSCAN STAGE RANGE. “Domengine.”

GEOGRAPHIC DISTRIBUTION. Simi Valley and upper Cuyama River, Ventura County, California.

LOCAL OCCURRENCE. LACMIP loc. 7489, CSUN loc. 374, and an inexactly known locality on west side of Chivo Canyon [= Oil Canyon].

REMARKS. Three specimens are known from the Llajas Formation. One is the holotype of *E. stevensi*, which is a crushed internal mold of an incomplete specimen. The other two are fragments, but test material is present.

The three paratypes of *E. stevensi* are, like the holotype, badly preserved. They are partial specimens that have been crushed and weathered. These paratypes, along with the holotype, represent the only reported specimens belonging to *E. stevensi*. The exact stratigraphic position from which the paratype material was derived is uncertain. According to the locality description given by Grant and Hertlein (1938:135), as well as the locality description in the CAS records, the paratype material is from Reyes Creek in section 23, T7N, R23W [= Reyes Creek quadrangle]. Reyes Creek, however, never cuts through section 23; rather, the creek is about 0.6 km west and south of section 23. Although Reyes Creek is mostly just outside of the geologic map of Givens (1974), only Eocene rocks are known to crop out along the creek.

Although the primary type specimens of *E. stevensi* are poorly preserved, treated as a whole, they do show paired ambulacra with closed petals and a nonpetaloid ambulacrum. Only one specimen, CAS paratype 28490.02, shows what appears to be a peripetalous fasciole. According to Fischer (1966), all these morphologic features are diagnostic of genus *Eupatagus*. The poor preservation of the primary type specimens of *E. stevensi* is trou-

blesome because it is difficult to compare these types with better preserved specimens. The two specimens from the Llajas Formation do appear to be conspecific with *E. stevensi*, and they add considerably to our knowledge of this species.

Figures 64 and 65 represent the first photographs of the holotype of *E. stevensi*. The only other illustration of this species has been a line drawing of the holotype (Grant and Hertlein, 1938:text fig. 12).

The only other species of *Eupatagus* reported from the rock record of the Pacific coast of North America is *E. batequensis* Squires and Demetron, 1992, from the “Capay Stage” part of the Bateque Formation in Baja California Sur, Mexico. *Eupatagus stevensi* is closely related to *E. batequensis* Squires and Demetron (1992:46, 48, figs. 142–145), but *E. stevensi* differs by having a less inflated test, wider petaloids on the bivium, slightly stronger primary tubercles, and primary tubercles closer to the margin of the test.

Phylum Chordata Balfour, 1880

Class Chondrichthyes Huxley, 1880

Order Lamniformes Berg, 1958

Family Odontaspidae Müller and Henle, 1839

Genus *Striatolamia* Glückman, 1964

TYPE SPECIES. *Otodus macrotus* L. Agassiz, 1843, by original designation?; Eocene, Paris Basin, France.

Striatolamia macrota (Agassiz, 1843)

Figures 68, 69

PRIMARY TYPE MATERIAL. Possibly stored in Bern, Switzerland.

MOLLUSCAN STAGE RANGE. Eocene.

GEOGRAPHIC DISTRIBUTION. California, Oregon, Washington, east coast of North America, Belgium, Paris Basin, Ukraine, Central Asia, Kazakhstan, Chile, and Seymour Island off Antarctica. For an extensive synonymy of this species, see Casier (1946).

LOCAL OCCURRENCE. CSUN loc. 374.

REMARKS. A single specimen is known from the Llajas Formation. The geographic distribution of this pantropical species is based on the following

Figures 58–72 Echinoids, odontaspid shark tooth, and bat ray tooth from Llajas Formation. 58–67. Echinoids. 58–61. ?*Brochopleurus* sp., LACMIP hypotype 12770, CSUN loc. 548. 58. Partial aboral surface, $\times 3$. 59. Enlargement of a portion of the aboral surface, $\times 12$. 60. Partial oral surface, $\times 2.7$. 61. Lateral view of test, $\times 2.5$. 62, 63. *Calilampas californiensis* Squires and Demetron, 1995, $\times 1.1$, LACMIP paratype 11532, LACMIP loc. 26622. 62. Dorsal view. 63. Left side. 64–67. *Eupatagus stevensi* Grant and Hertlein, 1938. 64–65. LACMIP holotype 9134, Chivo Canyon, Simi Valley, $\times 1.6$. 64. Dorsal view. 65. Right side. 66. Dorsal view, $\times 1.6$, LACMIP hypotype 12771. 67. Right side, $\times 1.3$, LACMIP hypotype 12772. 68–69. Odontaspid shark tooth. *Striatolamia macrota* (Agassiz, 1843), $\times 1$, LACMVP hypotype 144463, CSUN loc. 374. 68. Lingual view. 69. Distal view. 70–72. Bat ray tooth. ?*Myliobatis* sp., $\times 1$, LACMVP hypotype 144464, CSUN loc. 548. 70. Occlusal view. 71. Basal view. 72. Lingual view

reports: Welton and Zinsmeister (1980), Cappetta (1987), and Squires et al. (1992).

Order Myliobatiformis Compagno, 1973

Superfamily Myliobatoidea Compagno, 1973

Family Myliobatidae Bonaparte, 1838

Genus *Myliobatis* Cuvier, 1816

TYPE SPECIES. *Raja aquila* Linnaeus, 1758, by subsequent designation (Bory de Saint-Vincent, 1829); Recent, southern North Sea to Africa, including the Mediterranean Sea.

?*Myliobatis* sp.

Figures 70–72

LOCAL OCCURRENCE. CSUN locs. 471a, 548.

REMARKS. Two median teeth of this fossil bat ray are known from the Llajas Formation. The specimen from CSUN locality 471a is the one briefly mentioned by Squires (1984). Each tooth is an isolated chevron-tooth pavement. During the life of the animals, chevron-tooth pavements collectively formed a large battery of teeth that constituted a mosaic within the bat ray jaw. Both of the Llajas Formation teeth are 50 mm long and 8 mm wide, slightly curved with the occlusal face smooth, longitudinal ridges on the labial and lingual faces, and have many root grooves (about 10 per cm). The latter are subequal to slightly narrower than the intervening ridges.

Cvancara and Hoganson (1993) reported that isolated teeth of *Myliobatis* are overall very similar to those of the rhinopterid *Rhinoptera* Cuvier, 1829. The pavement teeth of *Myliobatis* differ from those of *Rhinoptera* by having more numerous and more closely spaced root lobes on the base (Case and West, 1991). The Llajas specimens are provisionally assigned to *Myliobatis* because they have numerous and more closely spaced root lobes. During the early Tertiary, *Myliobatis* was more widespread and had a greater species diversity than *Rhinoptera*. The latter is known only from the Old World and Brazil (Cappetta, 1987).

LOCALITIES

Unless otherwise noted, the topographic base map is the U.S. Geological Survey 7.5-minute Santa Susana quadrangle, 1951 (photorevised 1969), Ventura County, California, and the localities are in the “Domengine Stage” part of the Llajas Formation. Note that the present day intersection of Tapo Street and Los Angeles Avenue is benchmark 961 on the 1903 (reprinted 1924) edition of the Santa Susana quadrangle.

CSUN LOCALITIES

371. [Approximately = LACMIP 16654.] At elevation of 610 m on south side of a side canyon to

Devil Canyon, 389 m south and 350 m west of NE corner of section 26, T3N, R17W. Locality is in the Santa Susana quadrangle, but the section corner is in the 7.5-minute Oat Mountain quadrangle, 1952 (photorevised 1969). Collected by R. L. Squires, late 1970s.

374. [= LACMIP 22312 = LACMVP 6952 = UCMP 7004.] At elevation of 581 m on a small cliff on south side of a side canyon to Las Lajas Canyon, 594 m north and 556 m east of SE corner of section 29, T3N, R17W. Locality is in the “Stewart bed.” Collected by F. Jenkins circa 1970s and R. L. Squires, early 1980s.

444. At elevation of 483 m on a small cliff on north side of a side canyon to Las Lajas Canyon, 762 m north and 419 m east of SE corner of section 29, T3N, R17W. Locality is in the “Stewart bed.” Collected by R. L. Squires, M. Stettner, and G. Wood, May 1978.

471a. At elevation of 442 m on west side of an amphitheater on west side of Chivo Canyon, 183 m north and 655 m west of SE corner of section 30, T3N, R17W. Collected by R. L. Squires, December 1978.

473. At elevation of 502 m on a ridge, 320 m north and 701 m west of SE corner of section 30, T3N, R17W. Collected by R. L. Squires, December 1978.

548. [= LAMCIP 15450 = LACMIP 25837 = LACMVP 6953.] At elevation of 288 m on south side of Simi Arroyo just above the streambed, 335 m north and 533 m west of SE corner of section 12, T2N, R18W. Collected by R. L. Squires and several CSUN paleontology classes in the 1980s and 1990s and by G. Slak, 1997–1998.

1220b. Along a prominent ridge, north side of a minor canyon on the west side of Mesa La Salina, 84–130 m above the bottom of the exposures of the Bateque Formation in this area, approximately 1.25 km SE of the intersection of 113°00'W and 26°45'N [coordinates 1.6 and 59.4], Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982. Collected by R. L. Squires and R. A. Demetron, 1988–1990.

1291a. South side of a minor canyon near the southern end of Mesa La Salina at 120 m elevation, 112°56'13"W and 26°40'N, Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982. Collected by R. L. Squires and R. A. Demetron, 1989.

1544a. Along east side of reentrant on west side of Mesa La Salina, approximately 70 m above the bottom of the exposures of the Bateque Formation in this area [coordinates 4.35 and 55.70], Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982. Collected by R. L. Squires and R. A. Demetron, 1991.

1546. Near middle of east-facing cliff along canyon wall, near north end of Mesa La Azufrera, west

side of Arroyo La Tortuga, about 1 km south of abandoned village site El Cuarenta at 120 m elevation, 112°53'13"W, 26°38'55"N [coordinates 12.45 and 48.80], Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982. Collected by R. L. Squires and R. A. Demetron, 1991.

1573. In a "borrow pit" 228 m south and 548 m east of NW corner of section 23, T14N, R5W, 7.5-minute Doty quadrangle, 1986 (provisional edition), Lewis County, Washington. Collected by J. L. Goedert, 1993–1994.

1576. On southeast-facing cliff, south end of Mesa La Ladera at 80 m elevation, 112°52'45"W, 26°39'53"N [coordinates 13.20 and 50.75], Mexican government topographic quadrangle map (scale 1:50,000) of San José de Gracia (number G12A64), Baja California Sur, Mexico, 1982. Collected by R. L. Squires and R. A. Demetron, 1991.

1603. At elevation of 465 m along the west side of Temescal Canyon in an unsurveyed area of T1S, R16W, 5121 m south and 3917 m west of the NE corner of the 7.5-minute Topanga quadrangle, 1952 (photorevised 1967), Santa Monica Mountains, Los Angeles County, southern California. Collected by John Mack, 1991.

LACMIP LOCALITIES

7405. *Turritella* bed on west wall of Chivo Canyon, 3764 m N 23°E from intersection of Tapo Street and Los Angeles Avenue; locality is on north side of Simi Valley and 300 m stratigraphically above base of Lajas Formation. Collected by W. P. Woodring and K. E. Lohman, December 1929.

7418. East side of Devil Canyon, NE ¼ of NE ¼ of section 26, T3N, R17W, 7.5-minute Oat Mountain quadrangle, 1952 (photorevised 1969), southwestern Santa Susana Mountains, Ventura County, California. Collected by W. P. Woodring and B. L. Clark, June 15, 1928.

7430. In small canyon east of Chivo Canyon, 3901 m N 29.5°E from intersection of Tapo Street and Los Angeles Avenue on south side of Simi Valley; locality is on north side of Simi Valley and is 62 m stratigraphically above base of Lajas Formation. Collected by W. P. Woodring and K. E. Lohman, December 1929.

7434. [Approximately = LACMIP 7435 and LACMIP 7438.] Cliff face on west side of canyon; intersection of Tapo Street and Los Angeles Avenue is 3741 m to the south; locality is on north side of Simi Valley and approximately 67 m stratigraphically below contact with the Sespe Formation. Collected by W. P. Woodring, K. E. Lohman, and W. B. Maitland, June 15, 1929.

7435. [Approximately = LACMIP 7434 and LACMIP 7438.]. Collected by W. P. Woodring, K. E. Lohman, and W. B. Maitland, June 15, 1929.

7438. [Approximately = LACMIP 7434 and LACMIP 7435.]. Collected by W. P. Woodring, K. E. Lohman, and W. B. Maitland, June 15, 1929.

7445. North side of Simi Valley, 3990 m N 7°E from intersection of Tapo Street and Los Angeles Avenue; locality is 74 m stratigraphically below contact with the Sespe Formation. Collected by K. E. Lohman and W. B. Maitland, June 18, 1929.

7482. North side of Simi Valley in canyon; intersection of Tapo Street and Los Angeles Avenue is 4084 m S 16°W. Locality is 74 m stratigraphically above top of basal conglomerate of the Lajas Formation and 40 m stratigraphically above the Lajas Santa Susana Formation contact. Collected by W. P. Woodring, K. E. Lohman, and W. B. Maitland, June 15, 1929.

7489. South side of east fork of Chivo Canyon, 1052 m S 63°W of hill 2211 [= hill 2205 in section 29, T3N, R17W of the Santa Susana quadrangle, 1903 (reprinted 1924)]; north side of Simi Valley. Collector(s) unknown.

15450. [= CSUN 548.] Collected by J. E. Johnson, 1985.

16654. [Approximately same as CSUN 371.] Collected by UCLA paleontology students.

17115. Drill core samples from Atlantic Richfield Tapo oil well number 42, near center of section 36, T3N, R18W, in Tapo Canyon on north side of Simi Valley. Collected by E. H. Quayle, early 1930s.

20586. [Approximately = LACMIP 22371, probably approximately = LACMIP 16654.] SE ¼ of section 30, T3N, R17W, in Chivo Canyon, north side of Simi Valley. Collected by Kinnery and Sherman (date unknown).

21135. In north bank of stream that flows down canyon in front of steep bluff facing Las Lajas Canyon, 305 m east of county line, 152 m south of Las Lajas Canyon Road, Los Angeles County. Collector(s) unknown.

22312. [= CSUN 374.] Collected by W. P. Poppenoe, April 1946.

22371. [Approximately = LACMIP 20586.] Collected by M. Kelly and B. Myers, 1940.

22536. [= CAS 183.] North side of bend in Cowlitz River, southeast corner of section 28, T11N, R2W, 15-minute Castle Rock quadrangle, 1953, Lewis County, Washington.

25837. [Same as CSUN 548.] Collected by R. B. and L. R. Saul, April 26, 1968.

26617. On west side of Las Lajas Canyon, at elevation of 463 m, 396 m north and 191 m west of SE corner of section 29, T3N, R17W. Collected by H. Seiden, 1951.

26622. On east side of Las Lajas Canyon, at elevation of 602 m, 274 m north and 482 m east of SE corner of section 29, T3N, R17W. Collected by H. Seiden, 1951.

26624. On east side of Chivo Canyon, at elevation of 411 m, 533 m north and 178 m east of SW corner of section 29, T3N, R17W. Collected by H. Seiden, 1951.

CAS LOCALITIES

183. [= LACMIP 22536.]

244. In east bank of Liveoak Canyon, about 1.2

km from its mouth, 7.5-minute Pastoria Creek quadrangle, 1952 (photo revised 1974), Tehachapi Mountains, Kern County, California. Collected by F. M. Anderson and G. D. Hanna (Anderson and Hanna, 1925:39; Squires, 1989:46).

28490. Section 23, T7N, R23W, 7.5-minute Reyes Peak quadrangle, 1943, Reyes Creek, upper Cuyama River, Ventura County, California. Collected by J. B. Stevens, January 1936 (Grant and Hertlein, 1938:135).

68035. Section 28, T16N, R1E, 7.5-minute Sutter Buttes quadrangle, 1964 (photorevised 1973), Sutter Buttes [= Marysville Buttes], Sutter County, California. Collected by J. G. Cooper, November 1, 1863. [= California State Mining Bureau locality 13745] (Keen and Bentson, 1944:197; CAS registry files).

UCMP LOCALITIES

672. South portion of crest of Parson's Peak, SE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of section 24, T18S, R14E, 30-minute Coalinga quadrangle, 1912, Fresno County, California (Vokes, 1939:185).

2226. Rose Canyon, southeast of Soledad Mountain, 117°14'W, 33°50'N, 7.5-minute La Jolla quadrangle, 1967, San Diego County, California. Collected by R. E. Dickinson and W. S. W. Kew (Hanna, 1927:265).

3609. Exact location unknown, vicinity of Byron, 7.5-minute Byron Hot Springs quadrangle, 1953 (photorevised 1968), Contra Costa County, California.

3975. Elevation of 91 m on bluff 0.4 km SSE of benchmark 176, 3.2 km east of La Jolla, on east side of Rose Canyon, 7.5-minute La Jolla quadrangle, 1967, San Diego County, California. Collected by M. A. Hanna (Hanna, 1927:265).

5059. South of Sorrento station 0.6 km, elevation 69 m, 7.5-minute La Jolla quadrangle, 1967, San Diego County, California. Collected by M. A. Hanna (Hanna, 1927:267; Keen and Bentson, 1944:235).

5062. In sea cliff south of mouth of Soledad Valley, due west of midpoint between "P" and "u" of "Pueblo," 7.5-minute Del Mar quadrangle, 1967, San Diego County, California. Collected by M. A. Hanna (Hanna, 1927:267; Keen and Bentson, 1944:235).

7004. [= CSUN 374.] Collected by R. B. Stewart, July 23, 1969.

A-696 to A-700. On north bank of Umpqua River near section line between sections 29 and 30, T24S, R7W, 7.5-minute Tyee quadrangle, 1976, Douglas County, Oregon (Turner, 1938:38; Hoover, 1963:D-27).

A-836 and A-838. Bed of Middle Fork of Coquille River opposite Oregon Highway 42 [= Roseburg-Coos Bay Highway], SW $\frac{1}{4}$ of section 29, T29S, R10W, 7.5-minute Remote quadrangle, 1976, Coos County, Oregon. Collected by F. E. Turner (Turner, 1938:39).

A-973. Base of Domengine Formation on the north bank of Domengine Creek, section 30, T18S [not T19S, as reported], R15E, 30-minute Coalinga quadrangle, 1956, Fresno County, California. Collected by H. E. Vokes (Vokes, 1939:185).

A-976. Big Tar Canyon, Reef Ridge, T23S, R17E, 7.5-minute Garza Peak quadrangle, 1953, Kings County, California. Collected by H. E. Vokes (Keen and Bentson, 1944:237).

A-1281. Reef Ridge, T23S, R17E, near center of north edge of section 20, on hill slope immediately south of point where the Big Tar-McLure Valley road crosses saddle at head of stream running into McLure Valley, 7.5-minute Garza Peak quadrangle, 1953, Kings County, California. Collected by H. E. Vokes (Vokes, 1939:188).

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Appendix

Megafossils known with certainty from the Lajas Formation.

Sources of data: Squires (1984) and this report.

Corals

- Antilla batequensis* Squires and Demetron, 1992
Archohelia clarki Vaughan, 1927
Trochocyathus stantoni Vaughan, 1900
? *Trochocyathus striatus* (Gabb, 1864)
Turbinolia dickersoni Nomland, 1916

Brachiopods

- Eogryphus tolmanni* Hertlein and Grant, 1944
Terebratalia aff. *T. batequia* Sandy, Squires, and Demetron, 1995
Terebratulina cf. *T. tejonensis* Stanton, 1896

Polychaetes

- Rotularia tejonense* (Arnold, 1909)

Scaphopods

- Dentalium* (*Laevidentalium*) *calafium* Vokes, 1939
Dentalium stentor Anderson and Hanna, 1925

Gastropods

- Akera maga* Vokes, 1939
Amaurellina caleocia Vokes, 1939
Ancilla (*Spirancilla*) *gabbi* Cossmann, 1899
Ancistrolepis? *carolineae* Squires, 1984
Architectonica (*Architectonica*) *llajasensis* Sutherland, 1966
Architectonica (*Stellaxis*) *cognata* Gabb, 1864
Bathytoma pacifica n. sp.
Benoistia umpquaensis Turner, 1938
Bonellitia (*Admetula*) *paucivaricata* (Gabb, 1864)
Calorebama lineata Gabb, 1864
Calorebama inornata (Dickerson, 1915)
Calyptraea diegoana (Conrad, 1855)

- Cerithiopsis llajasensis* Squires, 1984
Cirsotrema eocenica Squires and Demetron, 1994
Clavilithes tabulatus (Dickerson, 1913)
? *Cochlespirospira jenkinsi* n. sp.
Colwellia cretacea (Gabb, 1864)
Conus hornii umpquaensis Turner, 1938
Cryptochorda (C.) *californica* (Cooper, 1894)
Cylichnina tantilla (Anderson and Hanna, 1925)
Cymatium (*Septa*) *janetae* Squires, 1983
Ectinochilus (*Macilentos*) *macilentus* (White, 1889)
Eocernina hambibali Dickerson, 1914
Eocithara mutica californiensis (Vokes, 1937)
Eocypraea (E.) *castacensis* Stewart, 1927
Eosurcula aff. *E. inconstans* (Cooper, 1894)
Euspira nuciformis (Gabb, 1864)
Exilia llajasensis Bentson, 1940
Ficopsis cooperiana Stewart, 1927
Ficopsis remondii crescentensis Weaver and Palmer, 1922
Fusinus teglandae Hanna, 1927
Fusinus aff. *Fusinus ucalius* Vokes, 1939
Fusiturricula (*Crenaturricula*) *crenatospira* (Cooper, 1894)
Fusiturricula (*Crenaturricula*) *crenatospira domenginica* Vokes, 1939
Galeodea (*Caliagaleodea*) *californica* Clark, 1942
Galeodea (*Mambrina*) *susanae* Schenck, 1926
Laevityphis (*Laevityphis*) *antiquus* (Gabb, 1864)
Lapparia eomagna (Vokes, 1939)
Lyria andersoni Waring, 1917
Lyrischapa lajollaensis (Hanna, 1927)
Megistostoma gabbianum (Stoliczka, 1868)
Mitra simplicissima Cooper, 1894
Natica (*Naticarius*) aff. *N. (N.) uvasana* Gabb, 1864
Neverita (*Neverita*) *globosa* Gabb, 1869
Olequahia domenginica (Vokes, 1939)
Olivella mathewsonii Gabb, 1864

Pachycrommium clarki (Stewart, 1927)
Paraseraphs erraticus (Cooper, 1894)
Phalium (*Semicassis*) *tuberculiformis* (Hanna, 1924)
Platyoptera pacifica Squires and Demettrion, 1990
Pleurofusua fresnoensis (Arnold, 1910)
Proximitra? *cretacea* (Gabb, 1864)
Pseudoperissolax blakei praeblakei Vokes, 1939
Pterynotus (*Pterynotus*) cf. *P. (P.) washingtonicus* Squires and Goedert, 1995
Ranella katherineae Squires, 1983
Ranellina pilsbryi Stewart, 1927
?Serpulorbis llajasensis Squires, 1990
Scaphander (*Mirascapha*) *costatus* (Gabb, 1864)
Sinum obliquum (Gabb, 1864)
Strepsidura ficus (Gabb, 1864)
Surculites mathewsonii (Gabb, 1864)
Terebra californica Gabb, 1869
Trypanotoma stocki (Dickerson, 1916)
Tejonia moragai (Stewart, 1927)
Turritella andersoni Dickerson, 1916
Turritella andersoni lawsoni Dickerson, 1916
Turritella buwaldana Dickerson, 1916
Turritella meganosensis protumescens Merriam and Turner, 1937
Turritella uvasana applinae Hanna, 1927
Turritella uvasana infera Merriam, 1941
Velates perversus (Gmelin, 1791)
Xenophora stocki Dickerson, 1916

Bivalves

Acanthocardia (*Agnocardia*) *sorrentoensis* (Hanna, 1927)
Acanthocardia (*Schedocardia*) *brewerii* (Gabb, 1864)
Acila (*Truncacila*) *decisa* (Conrad, 1855)
Anomia mcgoniglenensis Hanna, 1927
Barbatia sp.
Brachidontes (*B.*) *cowlitzensis* (Weaver and Palmer, 1922)
Callista (*Costacallista*) cf. *C. (C.) hornii* (Gabb, 1864)
Callocardia (*Nitidavenus*) *tejonensis* (Waring, 1914)
Cardiomya aff. *C. russelli* (Hanna, 1927)
Claibornites diegoensis (Dickerson, 1916)
Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922
Crassatella uvasana Conrad, 1955
Divaricella cumulata (Gabb, 1864)
Gari cf. *C. eoundulata* Vokes, 1939
Gari texta Gabb, 1864
Gastrochaena ?dubitata Hanna, 1927
Glycymeris (*Glycymeris*) *rosecanyonensis* Hanna, 1927

Glycymeris (*Glycymerita*) *sagittata* (Gabb, 1964)
Glyptoacis (*Claibornicardia*) *domenginica* (Vokes, 1939)
?Hilgardia parkei (Anderson and Hanna, 1925)
Macoma rosa Hanna, 1927
?Mactromeris merriami (Packard, 1916)
Marcia (*Mercimonia*) *bunkeri* (Hanna, 1927)
Nayadina (*Exputens*) *llajasensis* (Clark, 1934)
Nemocardium linteum (Conrad, 1855)
Nuculana (*Saccella*) *gabbi* (Gabb, 1869)
Ostrea idriaensis Gabb, 1869
Pinna lewisi Waring, 1917
Pinna llajasensis Squires, 1983
Pitar (*Calpitarina*) *uvasanus* (Conrad, 1855)
Pitar (*Lamelliconcha*) *joaquinensis* Vokes, 1939
Pitar uvasana coquillensis Turner, 1938
Pycnodonte (*Phygraea*) cf. *P. (P.) pacifica* Squires and Demettrion, 1990b
Pteria pellucida (Gabb, 1864)
Solena (*Eosolen*) *novacularis* (Anderson and Hanna, 1928)
Spondylus carlosensis Anderson, 1905
Teredo? sp.
Venericardia (*Pacificor*) *aragonia joaquinensis* (Vokes, 1939)
Venericardia (*Pacificor*) *hornii calafia* Stewart, 1930

Cephalopods

Aturia myrlae Hanna, 1927
Kummelonautilus sp.
Spirulimorph sepiid

Crabs

Glyphithyreus weaveri (Rathbun, 1926)
Parribacus caesius n. sp.
Palaeopinnixa aff. *Palaeopinnixa rathbunae* Schweitzer et al., 2000
Portunites insculpta Rathbun, 1926
Raninoides slaki n. sp.

Echinoderms

?Brochoplerus sp.
Calilampas californiensis Squires and Demettrion, 1995
Eupatagus stevensi Grant and Hertlein, 1938
Schizaster diabloensis Kew, 1920

Sharks and Rays

Isurus cf. *I. praecursor* (Leriche, 1906)
?Myliobatis sp.
Odontaspis sp.
Striatolamia macrota (Agassiz, 1843)